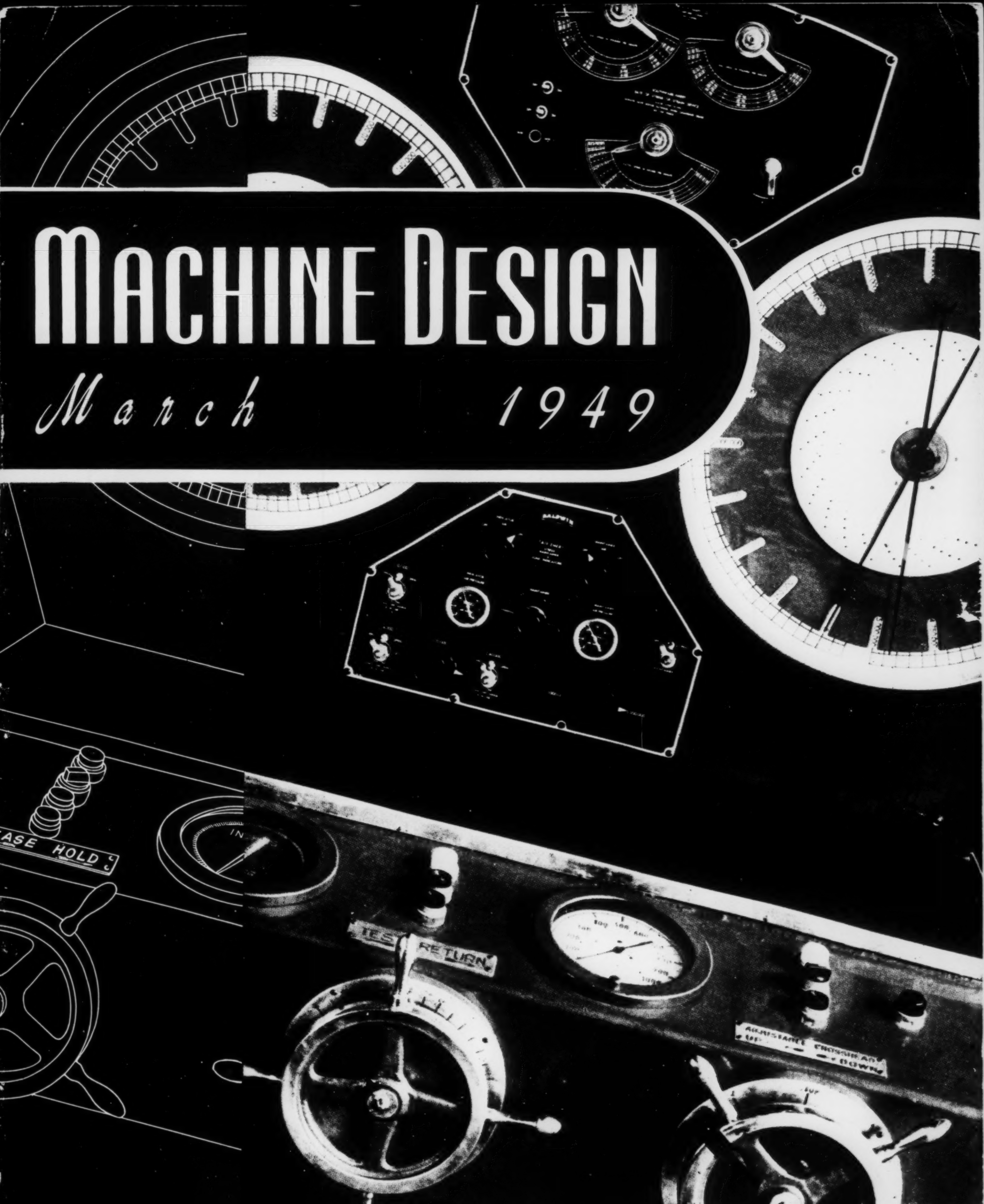
MACHINE DESIGN

March 1949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ADJUSTABLE CROSSHEAD
UP DOWN

In This Issue: **ENGINEERING MANAGEMENT . . . DESIGN TOLERANCES
DEVELOPING CREATIVE ABILITY . . . STYLING . . . NUMERICAL ANALYSIS**

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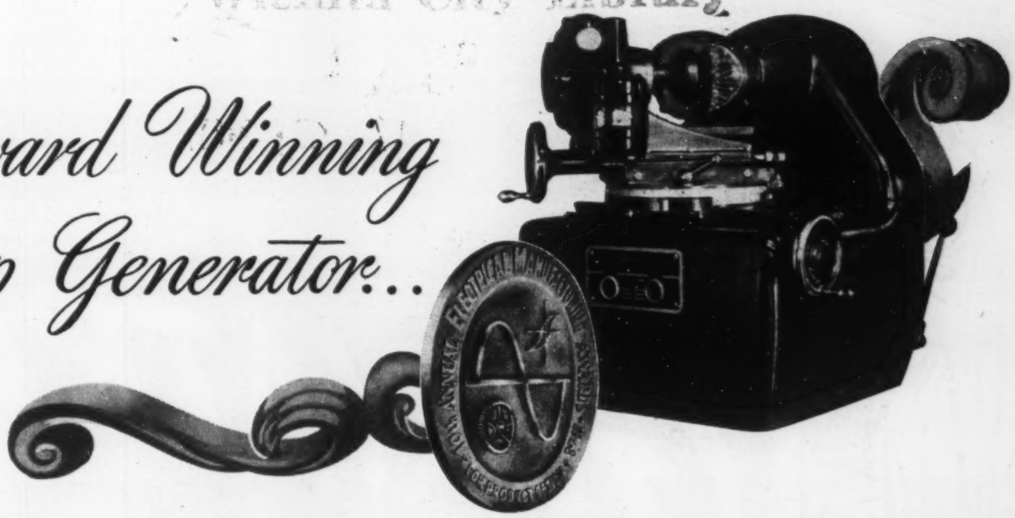

A Product Design Award was recently made by *Electrical Manufacturing* magazine to the Shuron Optical Company for excellence in the design of their sphere lap generator.

The Shuron machine is a type of machine used by all opticians. It retrues the metal grinding laps which are used with grinding or polishing compounds on the glass lens blank. Spherical curves, smooth to within 0.000035″, are generated on the lap by a carbide "face" milling cutter. The entire range of curves required in practice is covered by two cutters—interchangeable in a matter of seconds. The Shuron lap generator is a delicate unit used for precision grinding and is driven by a small Bodine speed reducer motor of one-twentieth horsepower.

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USES A

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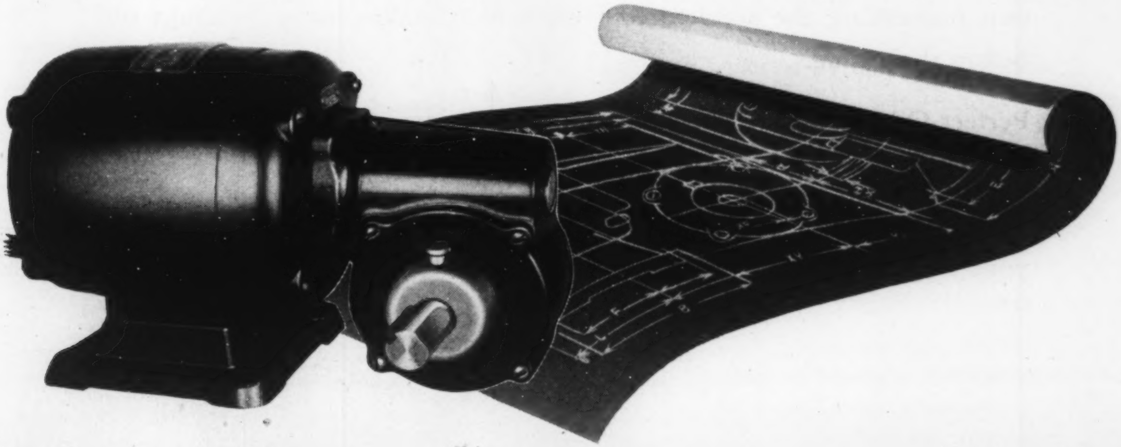

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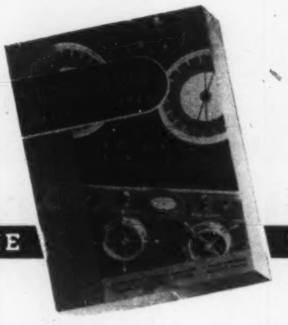
MACHINE DESIGN

Vol. 21—No. 3 **March, 1949**

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS



This Month's Cover: Control cabinet containing all elements necessary for application and measurement of load for world's largest universal testing machine at the Naval Air Experimental Station, Philadelphia.

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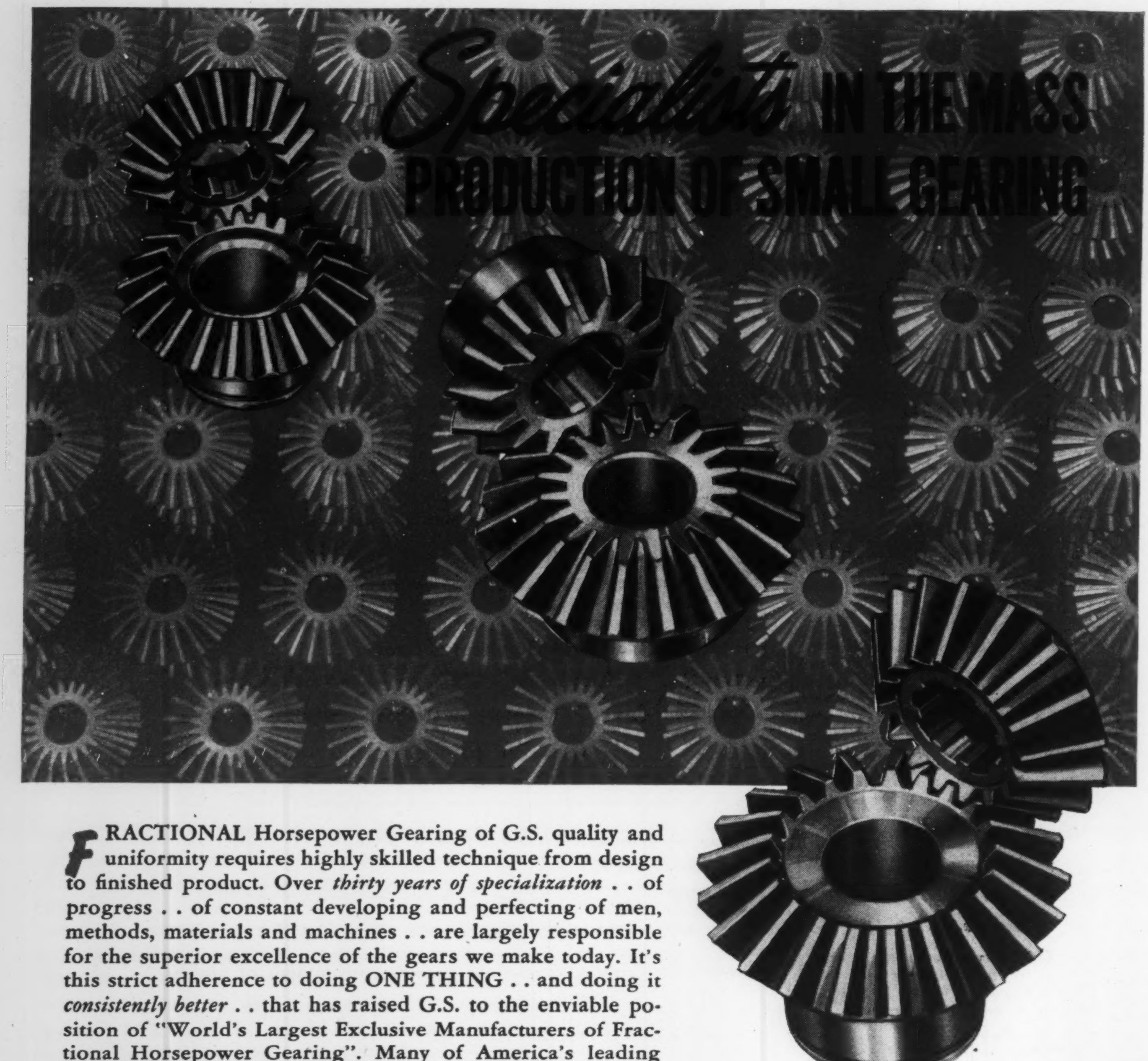

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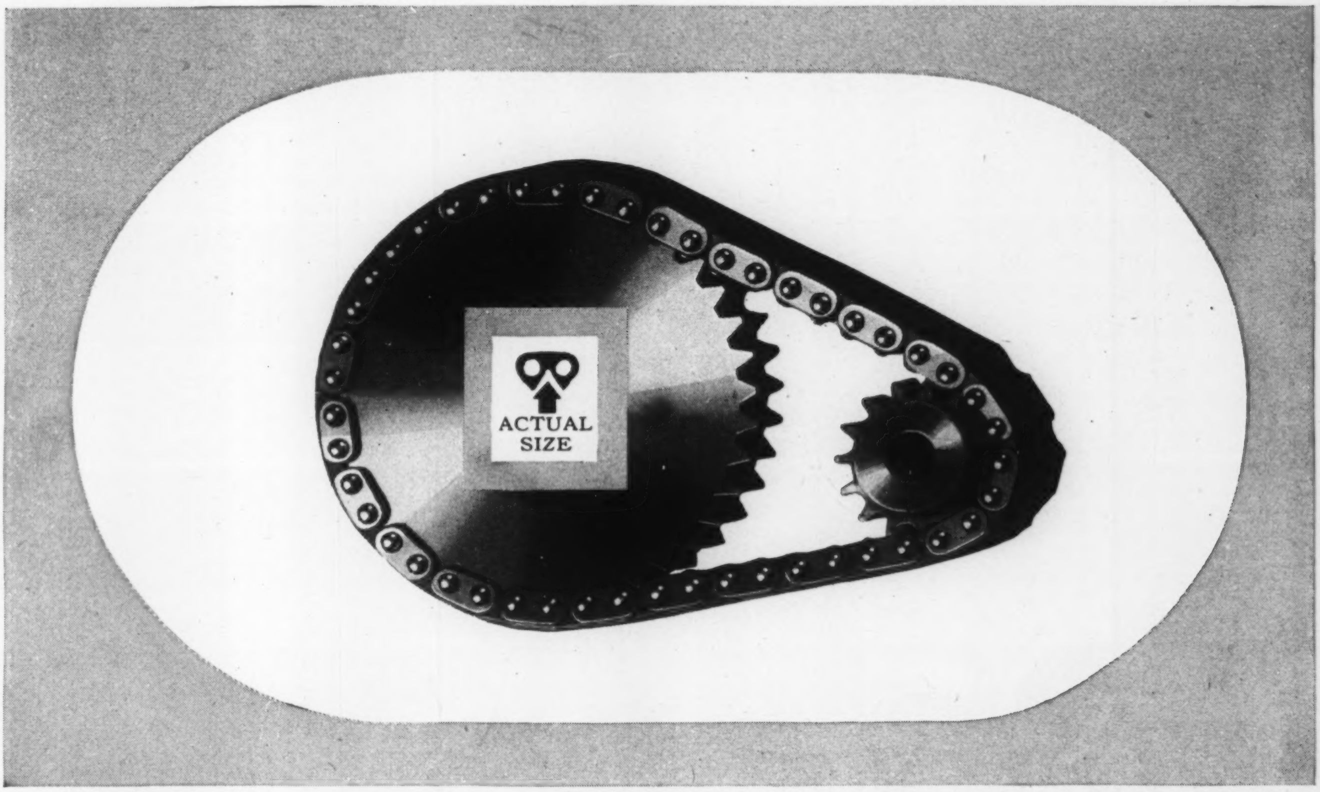

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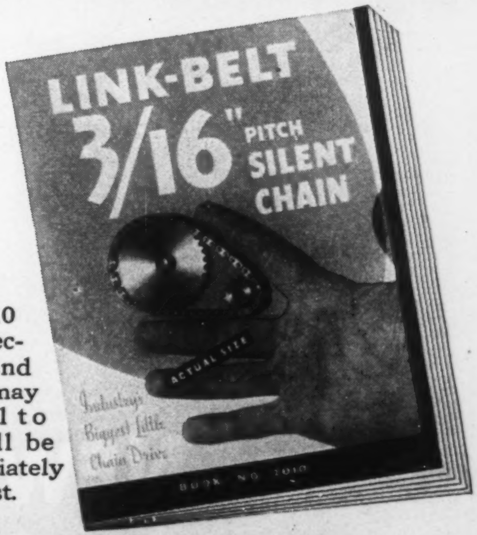

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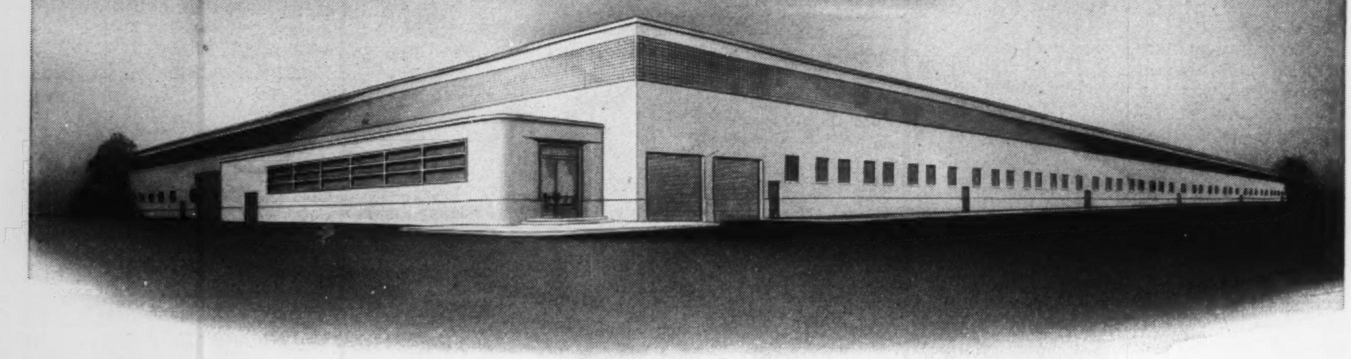

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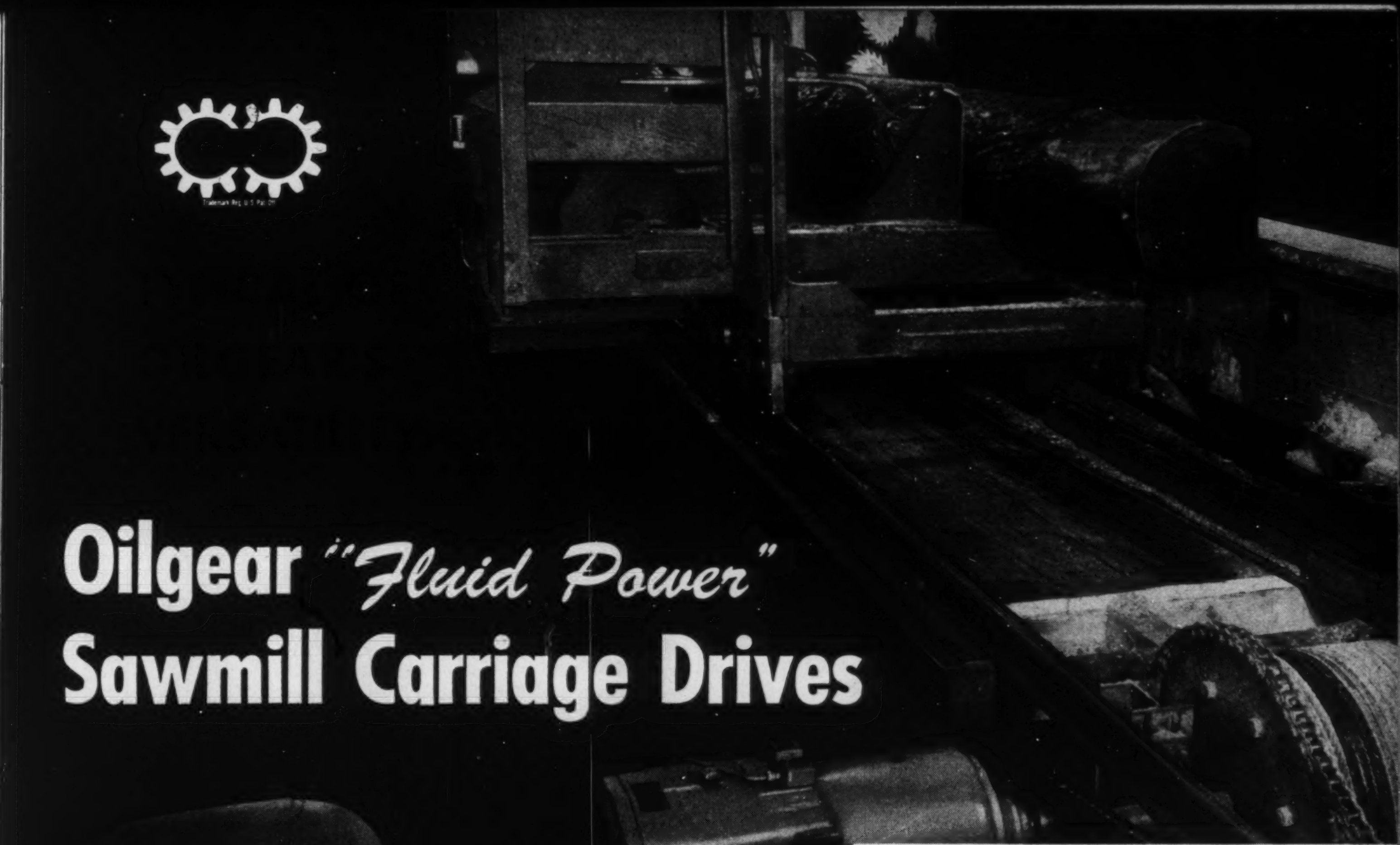

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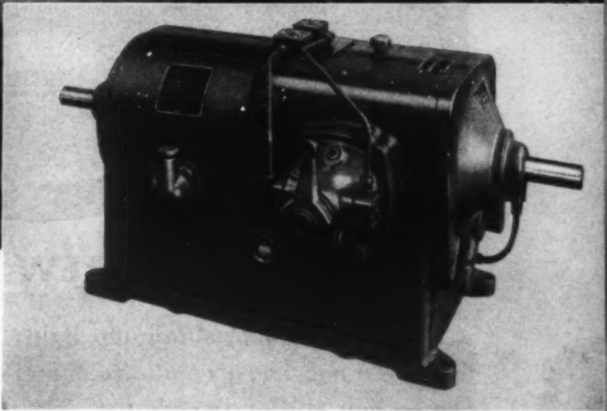

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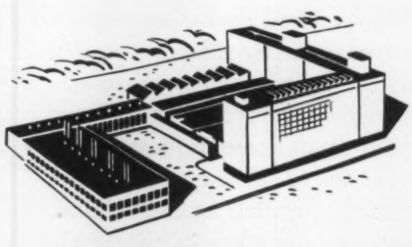

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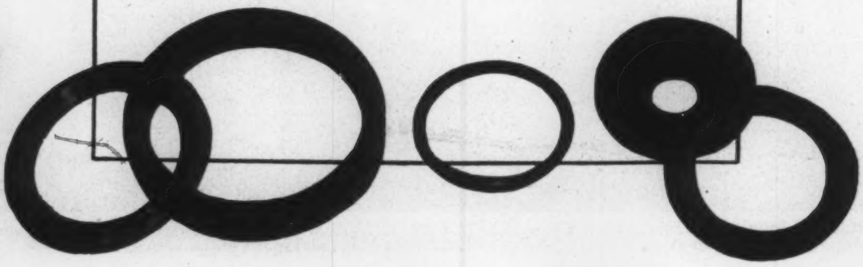
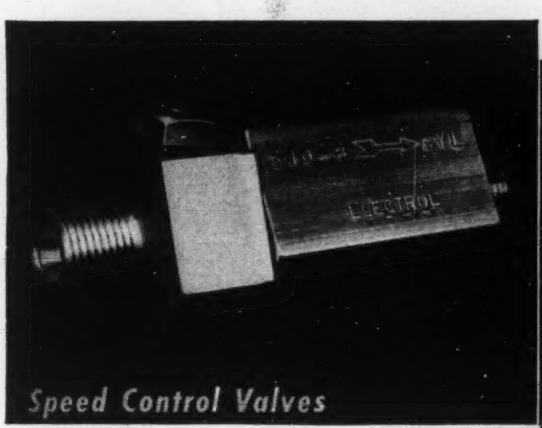
PACKINGS



Electrol Hydraulic Devices

For Every Industrial Need

Pictured here are but a few of the many hydraulic devices produced by Electrol for industry . . . transportation . . . and agriculture. We will gladly supply further details as to the application of these units in the machines you use or the products you make. Or—better still—have our engineers work with you in adapting them to any specific design.

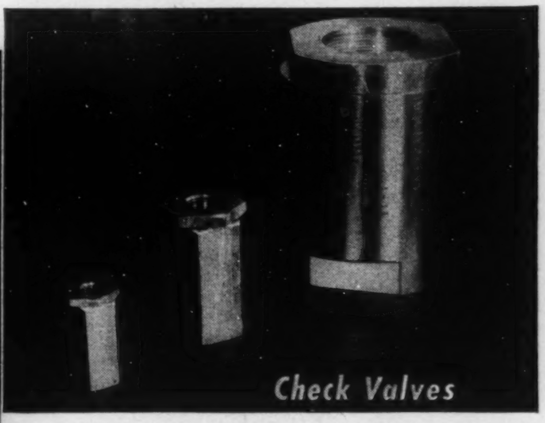


Speed Control Valves

Allow flow in one direction and, by use of a metering device, accurately control reverse flow from 0 to valve max.—even after thousands of cycles. Flow controlled by screw-actuated metering pin. Handle air or oil, with pressures up to 1,500 p. s. i. Standard sizes: ⅛, ¼, ⅜, ½ and ¾" N. P. T.

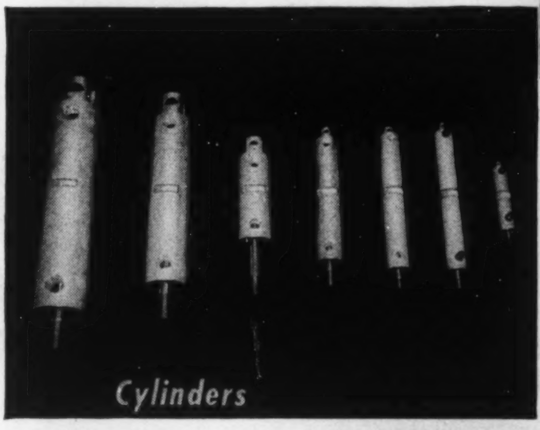
Hand Pumps

Uniform two-way action for maximum operating efficiency. Low in cost, economical in operation. Few moving parts, minimum of maintenance. Operating pressure: 0 to 1,500 p. s. i. Pump delivery: 1.5 cubic inches per cycle. ⅜" N. P. T. ports. Suction and pressure check valves built in.



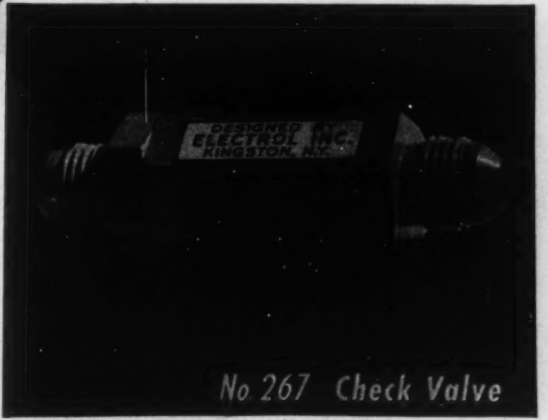
Check Valves

Provide positive sealing from low to high pressures—5,000 p. s. i. max. Used for air, gas, water and oil control with min. pressure drop and positive sealing against return flow. Standard models feature bronze and brass elements. Standard sizes: ⅛ to 2" N. P. T.



Cylinders

"500-1 Series" hydraulic cylinders available in bore diameters ranging from ¾" up to and including 3". Chromium plated piston rods, honed seamless steel tubing cylinders. Conventional "O" ring packings. Clevis mounting and standard pipe ports. Can be used in air or oil. Pressures up to 1,500 p. s. i.



No 267 Check Valve

Used to check flow of liquids, gas, air or water with pressure ranges up to 1500 p.s.i. Valve permits free flow through in one direction and prevents any flow in opposite direction. 9 port sizes, ranging from 5/16-24 NF-3 to 1-5/16-12 N-3, AN male threads; also, 6 sizes of male pipe thread, ranging from ⅛ 27 NPT to 1-11½ NPT. Specify thread type, size and fluid used when ordering.

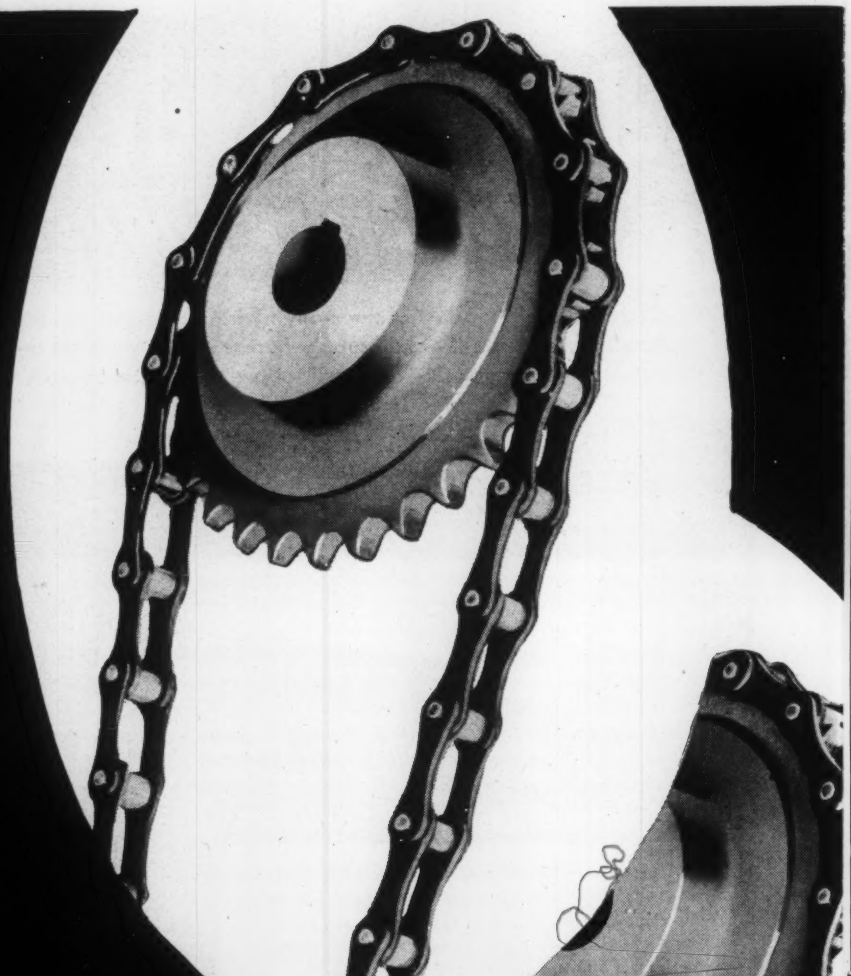
Electrol

INCORPORATED

KINGSTON, NEW YORK

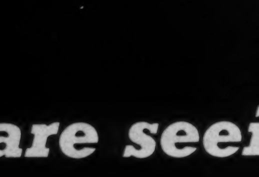
CYLINDERS • SELECTOR VALVES • FOLLOW-UP VALVES
CHECK VALVES • RELIEF VALVES • HAND PUMPS
POWERPAKS • LANDING GEAR OLEOS • SOLENOID
VALVES • ON-OFF VALVES • SERVO CYLINDERS • TRANSFER
VALVES • CUT-OUT VALVES • SPEED CONTROL VALVES

FOR BETTER HYDRAULIC DEVICES



Designers are seeing

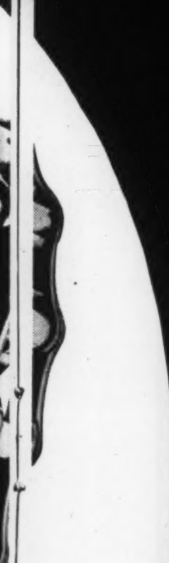
Made of standard roller chain round parts with double pitch side plates.



Weigh less than chains of comparable strength.

Can be used with cast tooth sprockets on many applications.

for lower costs, lighter weight



DOUBLE

More and more, cost-conscious designers are seeing the advantages of *double pitch* roller chain. For drive or conveyor service, where speeds range from slow to medium . . . loads light to moderate, double pitch chain offers you these important design advantages:

1. **CUTS COST.** Double pitch roller chain is lower in cost. In many applications, it can be used with cast instead of cut-tooth sprockets for even greater cost reductions.

2. **SAVES WEIGHT.** For a given strength, double pitch chain is lighter than other type chains.

3. **LONG-LIFE EFFICIENCY.** Double pitch chain uses standard long-lasting roller chain round parts with side plates of the same material as standard roller chains but double in pitch.

4. **UNIFORM WEAR.** Correctly applied, parallel strands of double pitch roller chains will wear evenly . . . an important advantage for conveying work.

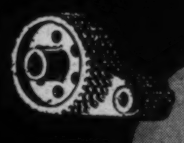
5. **SAVES SPACE.** Double pitch roller chain takes up less space . . . permits more compact design.

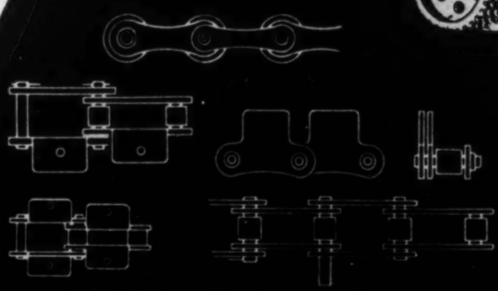
6. **VERSATILITY.** Double pitch roller chain operates efficiently on long or short centers.

7. **OVERSIZE ROLLERS.** For efficient, smooth conveyor service, double pitch chain can be furnished with oversize rollers.

Here's a chain that is built to the same exacting standards as standard roller chain . . . that gives you the same basic roller chain features . . . positive power transmission . . . shock-absorbing abilities . . . the ability to drive multiple shafts from a single power source . . . plus its own cost-cutting, weight-reducing advantages.

For all the facts, write Baldwin-Duckworth Division of Chain Belt Company, 320 Plainfield Street, Springfield 2, Massachusetts.

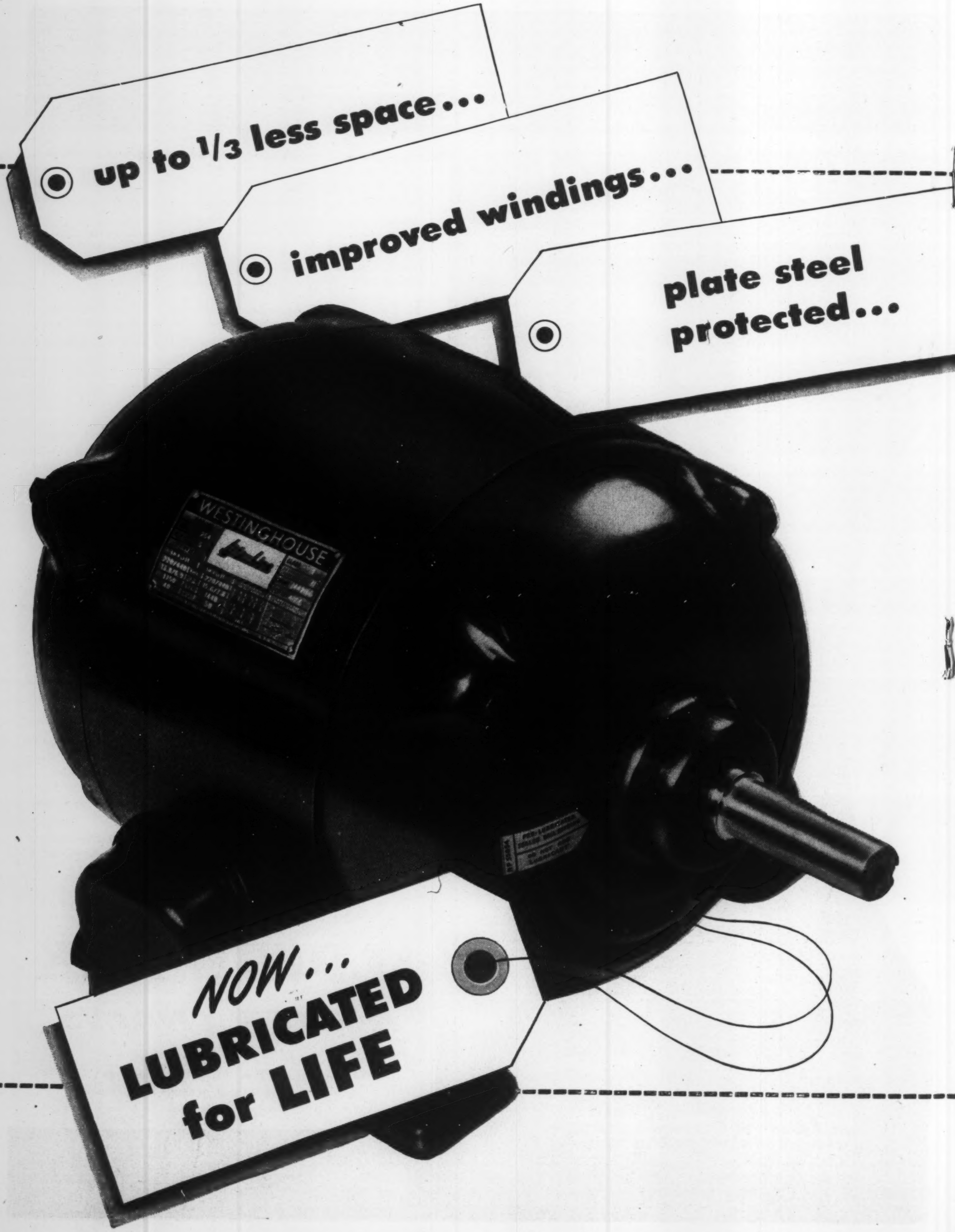




Have a full line of standard attachment links and can be furnished with oversize rollers for efficient, smooth conveyor service.

BALDWIN·REX
ROLLER CHAINS

A complete line from ¼-inch to 2½-inch pitch
Baldwin-Duckworth Division of Chain Belt Company


up to 1/3 less space...
improved windings...
plate steel protected...
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YOU CAN BE **SURE**.. IF IT'S

Westinghouse

—and NOW...

Lubricated for LIFE!

Now . . . for the first time . . . you can install electric motors, or motor-driven machines . . . and forget motor lubrication *for life!*

Westinghouse Life-Line . . . industry's amazing new, all-steel motor . . . now completely eliminates the biggest element in the maintenance of motors and motor-driven equipment . . . the need for periodic motor lubrication.

Eliminated, too, are two of the most frequent causes of motor burnouts and lost time . . . overgreasing and undergreasing of motors. Life-Line motors are equipped with sealed bearings, pre-lubricated for life with a more-than-ample supply of specially-treated lubricant.

Correct lubrication and long life are assured ...machine outages are reduced...motor drive problems are simplified, since motors can be located without need for constant accessibility.

Added to Life-Line's outstanding advantages of plate-steel protection, improved windings and more compact size, *lifetime lubrication* is one more important reason for starting to convert, today, to Life-Line power. Standard ratings are available from stock—others on short delivery schedules. Ask your Westinghouse representative for price and delivery on your requirements, or write P. O. Box 868, Pittsburgh 30, Pennsylvania. J-21495

Westinghouse Life-Line Motors

FIRST....
GITS ROTO-FLEX SHAFT SEAL

NOW the GITS UNIT SEAL

A Completely Self Contained Face-Type Shaft Seal

For improved seal performance on *Horizontal, Vertical and Inclined* Rotating Shafts.

For *High* or *Low Speed* applications with *Low Pressure.*

For performance well beyond present accepted oil seal standards.

THESE FEATURES OF ACHIEVEMENT will answer your Shaft Sealing Problems

✱ Here is positive sealing complete in one package—both rotating and stationary surfaces built into metal cartridge and factory assembled to rigid specifications.

✱ You don't have to prepare hardened and lapped rotating seal surface of any kind—no loose parts.

✱ No wear on shaft, bearing race or other surfaces of machine or pump.

✱ Low cost.

✱ Simple, fool-proof installation.

✱ Positive seal always.

Remember—your machine is only as good as the seals you use—use the Gits Unit Seal and profit from 40 years of seal designing and manufacturing experience.

Just Tell Us . . . .

1. *Shaft R. P. M. and direction.*
2. *Type of liquid to be sealed.*
3. *Temperatures and pressure ranges.*
4. *Any special operating conditions.*
5. **Be Sure** *to send us your dimensioned drawing for recommendation.*

Write today *for new illustrated literature on the Gits Unit Seal. Engineering data and helpful suggestions included. FREE!*

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TRANSPARENT AND STEEL WICK FEED OILERS
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SHOULDER DRIVE OIL HOLE COVERS
BRASS ELBOW OIL CUPS
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BEADED OIL HOLE COVERS
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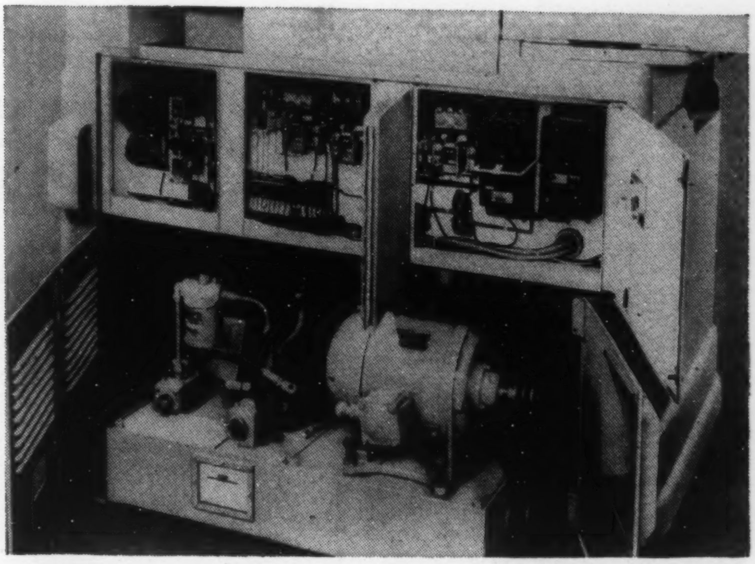
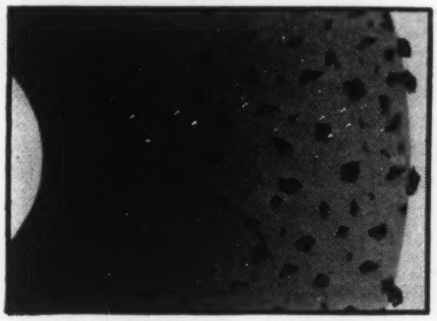
Protecting the Precision in Precision Machinery

The pumps, proper functioning of the control valves, and pistons in the hydraulic system controlling the automatic cycling and operation of this Heald Machine Company Centerless Grinder and other Heald precision machines, are protected by Cuno MICRO-KLEAN Filters to assure maintaining closest tolerances.



Guaranteed fluid conditioning . . . double cartridge life



Positive Cleaning . . . Greater Capacity

Cuno is the only manufacturer of replaceable-cartridge filters *guaranteeing* to remove all solids larger than specified, plus a large proportion down to 1 micron. MICRO-KLEAN's exclusive "graded-density-in-depth" permits smaller particles to penetrate to varying depths, eliminates surface loading, *doubles dirt holding capacity*. Resinous impregnation and polymerization prevents channeling, rupturing, shrinking and distortion.

Wide Range of Applications

Cuno MICRO-KLEAN filters come in varying densities . . . capacities from a few to more than 800 gpm . . . connections from ⅜ in. IPS to 6 in. flanged . . . single or multiple cartridges to handle full flow. MICRO-KLEAN cartridges fit other makes; special lengths available for built-in installations.

● Your nearby Cuno engineering representative, handling the broadest line of fluid filters, is your best source of unbiased recommendations on fluid filtration . . . he offers you, before and *after* installation, service based on years of experience with engineering filtration systems.

Send Coupon
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Cuno Engineering Corporation
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Please send information on Cuno Filter.

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Fluid Conditioning

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MICRONIC • DISC-TYPE • WIRE-WOUND

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How violent? Where heading? How fast?

Hurricane warnings that save so many lives on land and sea—where do they come from? From seismograph recorders, perhaps better known for their earthquake-locating power. These sensitive instruments, stationed all over the country and on Atlantic and Pacific island outposts, locate and plot the minute-by-minute movement of violent atmospheric disturbances . . . and pen the vital data on tape.

The heart of each of these life-savers is a Telechron Timing Motor . . . *instantly, constantly synchronous.* No other motor could be trusted with the tremendous responsibility of feeding facts to the scientists who dedicate their time and talent to this most important work.

Have you a timing problem?

What variable factors do you want to control or record with split-second accuracy? The chances are that the correct application of a standard Telechron Motor is the answer to your problem. A Telechron Application Engineer can quickly tell you. Consult him early in your planning and save time and trouble. In the meanwhile, fill in and mail the coupon below today for up-to-the-minute facts about Telechron Synchronous Motors.

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Telechron Inc. A General Electric Affiliate
20 Union Street
Ashland, Massachusetts

Please send me information on Telechron Synchronous Motors (maximum torque: 2 pound inches at 1 rpm). My possible application is:

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- ☐ Timers
- ☐ Electric Appliances
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COMPANY___________________________

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CITY______________ ZONE_____ STATE__________

Cork takes the "Creep" out of rubber gaskets

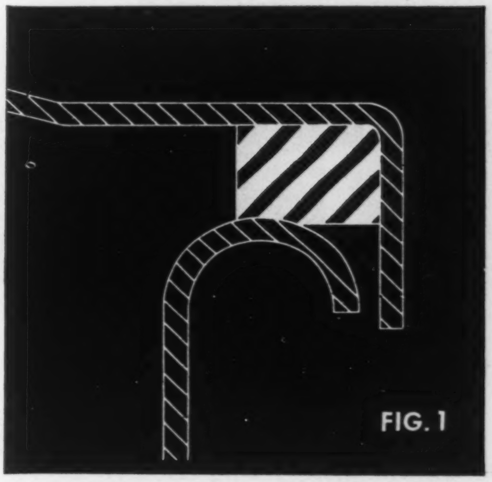


FIG. 1

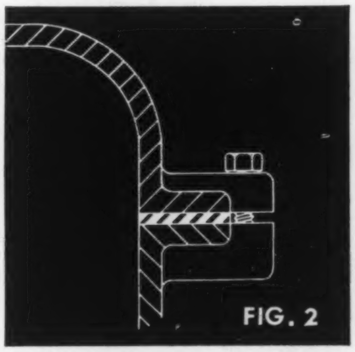


FIG. 2

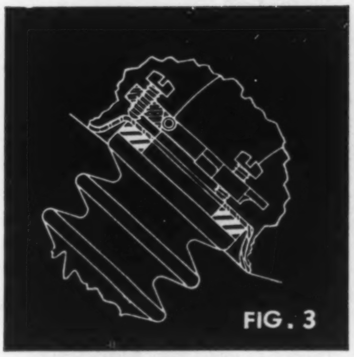


FIG. 3

Straight synthetic rubber is an excellent gasket material—except for one shortcoming. It side flows under pressure and tends to "creep" out of place. Even when properly seated during assembly, a straight rubber gasket may later creep enough to cause a failure in the field.

To eliminate creep, a truly compressible material, like Armstrong's cork-and-rubber, is used. Truly compressible materials do not side flow. They deflect only in the direction of the applied load. Consequently, they do not tend to creep. And with most fluids, the resistance of cork-and-rubber is equal to comparable straight synthetics.

Cork-and-rubber simplifies many sealing jobs. Take, for example, the problem of sealing the rolled edge tank shown in figure 1. Pressure-tight sealing of these tanks requires an impervious gasket. But straight rubber tends to creep off the rolled edge and slip into the tank.

Armstrong's cork-and-rubber, on the other hand, conforms to the rolled edge. It won't slip. And it holds the required pressure as well as straight rubber.

Figure 2 shows the flange of an oil-filled, water-immersed unit. Even under these conditions, truly compressible cork-and-rubber gaskets seal without creep.

The porcelain transformer bushing in figure 3 is sealed by a truly compressible cork-and-rubber gasket. The porcelain is safely cushioned against breakage. And even if flanges are oily, creep is retarded by the surface friction provided by the exposed cork particles.

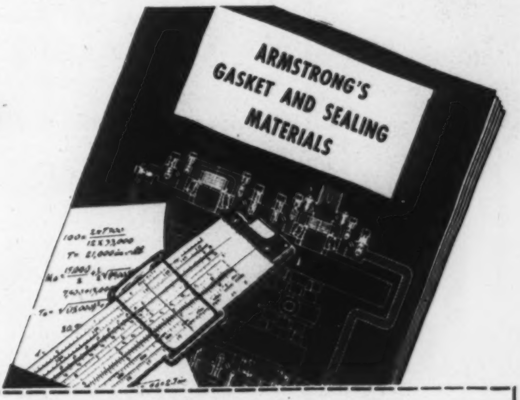
Versatile cork-and-rubber may help solve your sealing problems, too. Your Armstrong representative may be able to suggest methods and materials to help simplify construction and reduce cost. He will supply samples of materials for experimental use. Call your nearest Armstrong office today.

Send for this Gasket Handbook

You'll find useful application and specification data in the new, enlarged 24-page booklet, "Armstrong's Gasket and Sealing Materials." It contains up-to-date data on synthetic rubber, cork-and-synthetic-rubber, cork composition, and fiber sheet sealing materials.

This booklet includes ten technical discussions of the factors influencing modern gasket and joint design. It also suggests methods of putting Armstrong's stock materials to specialized uses in such fields as radio, electrical, automotive, petroleum, and transportation industries. Also included are typical applications and current government specifications.

For your free copy, fill in coupon at right and mail today.



ARMSTRONG'S
GASKETS · SEALS · PACKINGS

Cork Compositions • Cork-and-Synthetic-Rubber Compositions
Synthetic Rubber Compounds • Cork-and-Rubber Compositions
Fiber Sheet Packings • Rag Felt Papers • Natural Cork

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Gaskets and Packings Dept.
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Please send me at once a copy of the new 24-page booklet, "Armstrong's Gasket and Sealing Materials."

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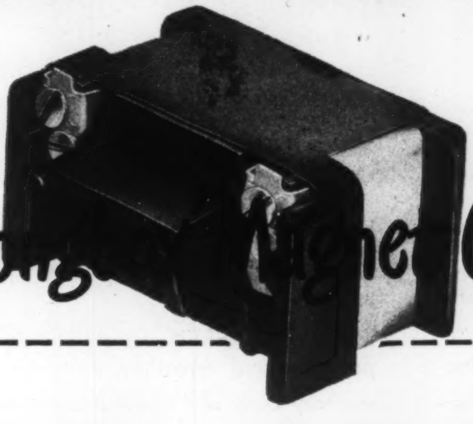
NEMA Sizes 0, 1, 2, 3
for a-c motors
up to 50 hp

GENERAL ELECTRIC

a complete NEW line

G-E MOTOR STARTERS

with the 'Strongbox' Magnet Coil



Here it is—a completely new line of G-E motor starters—full-voltage starters made for extra-long life, faster installation. Designed for easy maintenance, but built so you can forget them.

NEMA Sizes 0, 1, 2, and 3—each size new all the way through. Everything's new—contacts, arc hood, magnet, armature, and the tough Strongbox magnet coil. Get your first G-E starter and compare!

ORDER TODAY!

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Sec. AE676-277
Schenectady 5, N. Y.

Please send me your bulletins descr
GEA-5153 (CR7006 A-c Magnetic S
GEA-5156 (CR7008 A-c Combinatio
Name
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all new all the way thru

Tolerances in "TENTHS" 100% Practic for *Irregular Contours*

Automotive Pump Rotor
Generated on the Standard 7-Type
Fellows High Speed Gear Shaper.

Do you have a product design that calls for the use of close-tolerance, symmetrical or irregularly-shaped parts that must be produced without wastefully extravagant costs? If so, you would do well to investigate the design advantages and production economies that can be gained with the versatile Gear Shaper.

For example, in generating the inner member of the pump rotor shown above, the Gear Shaper reduces time, labor and costs—by requiring but a single work set-up, and by cutting one piece every 75 seconds.

Again, there is the inherent precision of the Fellows machine and Fellows cutter which holds accuracy under positive control, and insures that the contours of the inner member be exactly conjugate to those of the mating outer member, within the specified tolerance of .001 to .0015". Also, that this pump part is free to rotate—yet with such "tight" clearance as to permit pumping pressures up to 100 lbs. p.s.i.

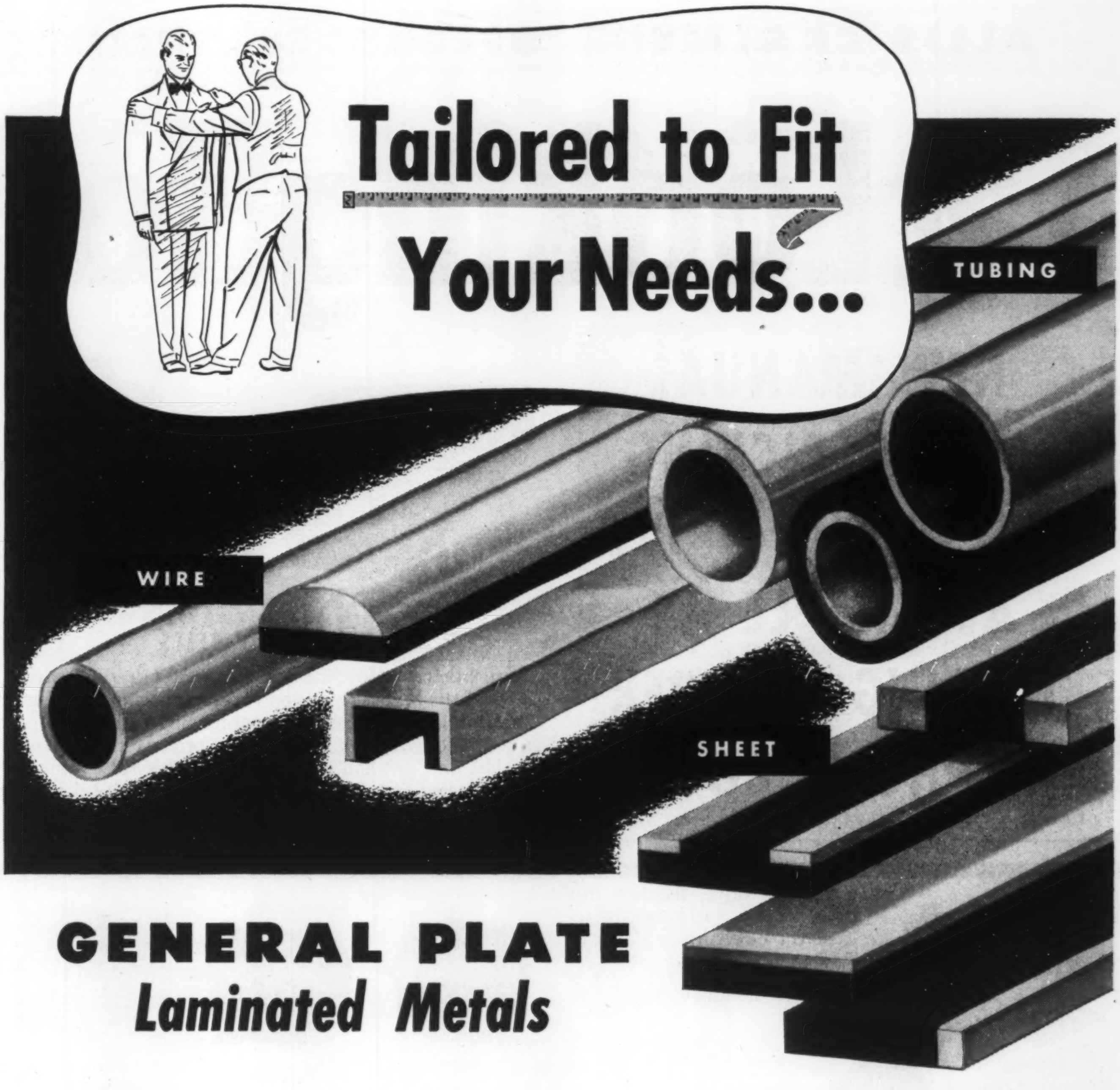
For a study of the broad range of Gear Shaper precision and versatility, write for your complimentary copy of "The Art of Generating with a Reciprocating Tool".

Fellows

THE FELLOWS GEAR SHAPER COMPANY

Head Office and Export Dept., Springfield, Vermont. Branch Offices: 616 Fisher Bldg., Detroit 2; 640 West Town Office Bldg., Chicago 12; 7706 Empire State Bldg., New York 1.

THE FELLOWS METHOD . . . MACHINES AND TOOLS FOR ALL OPERATIONS FROM BLANK TO FINISHED GEAR



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GENERAL PLATE
Laminated Metals

What are *your* metal problems? Do you need economical, non-corrosive metal with good workability? Do you need electrical contact parts with plenty of spring? Do you need contacts that have high conductivity yet light weight? Do you need contacts that are easily spot welded? The General Plate Laminated Metals are just the answer to your problems. These versatile metals are tailored to *your specific needs.*

Made by permanently bonding silver or other precious metal to inexpensive base metal, they give you the combined advantages of both metals . . . at a much lower cost than solid precious metals.

General Plate Laminated Metals are available in flat stock, coils, tubing and wire, electrical contacts of all types, and special contacts fabricated to your own design. Send for information and samples.

I-349

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SEND FOR FREE SAMPLES...

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Please send me information and samples of General Plate Laminated Metals.

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ALLIS-CHALMERS OFFERS EQUIPMENT

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NEW MANUAL MAKES PICKING THE RIGHT DRIVE AS SIMPLE AS FINDING NUMBER IN PHONE BOOK!

Then take one more step! Choose a *Texrope* drive, the line that gives you the world's widest selection of V-belt drive equipment. *Texrope, Super 7, Texiron, Texsteel, Texdrive, Magic-Grip, Vari-Pitch, Electrifugal* are Allis-Chalmers trademarks.

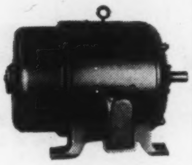
A, B, and C belts made in laminated construction

D and E belts made in twin cable construction

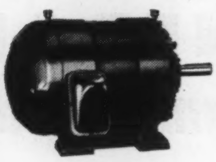
FHP belts in cable cord construction

TEXROPE V-BELTS

Available for quick delivery in *all standard sizes and lengths.* These belts have a reputation for smooth, long lasting performance. Cords float on a cool-running cushion that absorbs shock. Duplex sealed cover protects pulling cords against dirt, grit and moisture. *Super* 7 V-belts furnished in laminated and twin cable construction. FHP belts made in cable cord construction, for easy flexing over small diameter sheaves.



D-c Motor



Totally-Enclosed Fan-Cooled

Splash-Proof

Gear Motor

Totally Enclosed

MOTORS — 1/2 TO 200hp AND UP

Shown are a few of many motor types available to designers from Allis-Chalmers broad motor line. For tough operating conditions, use totally-enclosed, fan-cooled induction motors. Dust, dirt, acid fumes or moisture in the cooling air passes around the stator structure without coming in contact with the windings.

One of the Big 3 in Electric Power Equipment
Biggest of All in Range of Industrial Products

ALLIS-

AID TO MACHINE DESIGNERS!

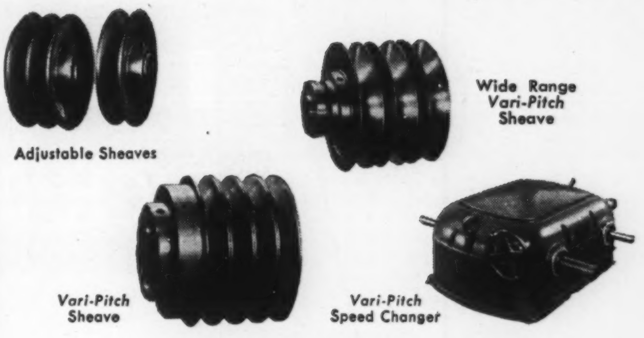
V-Belt Drives?

Standard Sheave
Texsteel and Texdrive Sheaves
Magic-Grip Sheaves
Special Sheaves

CONSTANT SPEED DRIVES

Good balance, smooth operation, neat, durable finish, feature the 4 types of Constant Speed *Texrope* drives.

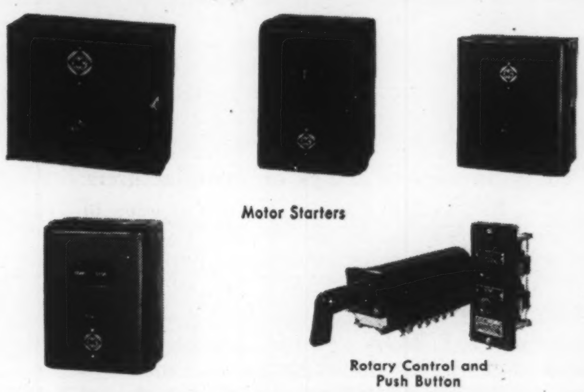
Type Sheave	Belt Sizes	Hp	Number Grooves
Texiron, Texsteel, Texdrive	A, B	¼-25	1-6
Magic-Grip	B, C, D	5-150	2-12
Standard Cast Iron	A, B, C, D, E	2-250	1-14
Special Cast Iron or Steel	A, B, C, D, E	1-1000	Any No.


Adjustable Sheaves
Wide Range Vari-Pitch Sheave
Vari-Pitch Sheave
Vari-Pitch Speed Changer

ADJUSTABLE SPEED DRIVES

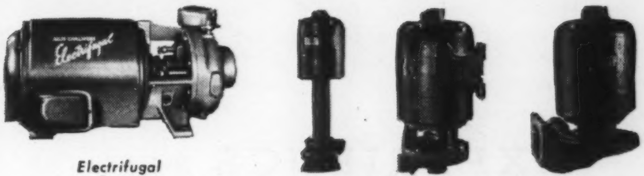
You can adjust the speed of the driven machine to operating conditions . . . Synchronize machines, increase production with these variable speed drives.

Type Sheave	Speed Range	Hp	Grooves	Belt Sizes
Vari-Pitch	to 25%	1-300	2-12	A, B, C, D, E
Wide Range *Vari-Pitch*	to 100%	½-30	1-4	Q, R
Vari-Pitch Speed Changer	to 375%	1½-75	1-5	Q, R, S, T


Motor Starters
Rotary Control and Push Button

CONTROL—ANY TYPE OR SIZE

Across-the-line starters for a-c motors range from size 0 to 7. These, together with manual or magnetic, full or reduced voltage starters for industrial applications, serve any size of motor. A variety of enclosures is available. Control devices include standard and heavy duty pushbutton stations, rotary switches, voltage regulators, contactors and relays.


Electrifugal
Electrifugal Pump
Coolant and Circulating Pump

PUMPS—10 TO 10,000 gpm

Permanent alignment of pump and motor on general purpose *Electrifugal pumps* is assured because both the bracket and flange supporting the pumps are cast integral with the motor frame. Sizes and capacities: 15 to 1600 gpm; heads to 180 ft.; motors ¾ to 25 hp. *Coolant and circulating pumps* for general or machine tool use are available on quick delivery.

A 2460

Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.

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Pre-Engineered *Texrope* Drives.. ☐
Variable Voltage Planer Drive data sheet.............................. ☐
Handy Guide for Quick Selection of Electric Motors (51B6052H)... ☐
Handy Guide to Selection of Centrifugal Pumps (53B6059D)... ☐
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MD A2460

CHALMERS

INSUROK
By
RICHARDSON

dependable
names in
plastics

EXPERIENCE is just one of the factors that make the names of INSUROK and Richardson more significant to manufacturers whose products require laminated or molded plastics. Richardson customers benefit from this experience in many ways.

(1) Richardson experience with a wide variety of plastic materials helps you select the one that accomplishes your purpose most effectively, efficiently and economically.

(2) Richardson experience in the design and production of Laminated INSUROK and Molded INSUROK products has resulted in savings to scores of manufacturers.

(3) Richardson's many proven grades of Laminated INSUROK are available in sheet, rod or tube stock or in fabricated, punched or post-formed component parts for an endless variety of applications.

(4) INSUROK plastic products and Richardson services have played an important part in the development and refinement of many products.

It might be to our mutual advantage to know how these materials and services can work for you.

INSUROK is a registered trade-mark of The Richardson Company

The RICHARDSON COMPANY
GENERAL OFFICES: LOCKLAND, OHIO   FOUNDED IN 1858
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Wichita City Library

NATIONAL OIL SEAL LOGBOOK

NEW OIL SEAL DEVELOPMENTS SOLVE EXTREME PROBLEMS

A practical, economical answer to many modern sealing problems is found in newly-developed shaft seals with sealing members of compounded synthetics. Common-sense chemistry, engineering, tooling and production have broadened the usefulness of these seals to where they account for a large percentage of all oil seals in use today.

ADVANTAGES AND LIMITATIONS OF THE NATIONAL 50,000-S SYNTECH OIL SEAL

The National 50,000-S (Fig. 1) is a metal encased, spring loaded single member Syntech Seal. Correct compounding of the synthetic rubber sealing member has made these seals capable of continuous operation with zero leakage at temperatures exceeding 300°F, speeds of 3600 F.P.M. and runout up to .030 indicator reading. However, these seals should only be used where there is sufficient and constant lubrication within the sealing area.

Sensitive Sealing Members

An important factor in this outstanding zero-leakage performance is the high sensitivity of the synthetic sealing member to the shaft surface. If shaft surfaces are finished to 15 to 20 R.M.S., or finer, and operating conditions are good, a seal life of several years may be expected. However, these seals are performing well on shaft finishes of 30 to 60 R.M.S. Such durability and performance makes these seals ideal for engines, pinions, transmissions and high-speed gear assemblies of all types.

Typical Application

In automotive transmissions such as shown in the section drawing (Fig. 2) the National 50,000-S is ideal. In such applications the shaft often turns at over 4000 R.P.M. and all types of extreme pressure lubricants are present. Many times there is a considerable head of oil at the seal and temperatures reach 300°F.

On Heavy Duty Equipment

Usefulness of the synthetic rubber seal is not limited to high-speed, precision-built machines. More and more these seals are replacing cumbersome "face" type or other seals on heavy duty equipment such as road graders, tractors and farm implements. The National Syntech Seal should be considered for any application where temperatures are over 200°F, speeds over 2000 R.P.M. or runout over .005 indicator reading.

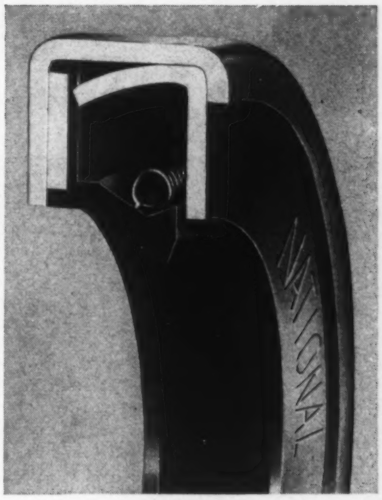

Figure 1

A marked advantage of synthetic spring-loaded seals is their wide availability. These designs are very well tooled, and synthetic-rubber National Oil Seals are available from stock in many types and sizes. National Oil Seal Engineers, who have pioneered research in compounded synthetics for fluid sealing, invite your inquiry.

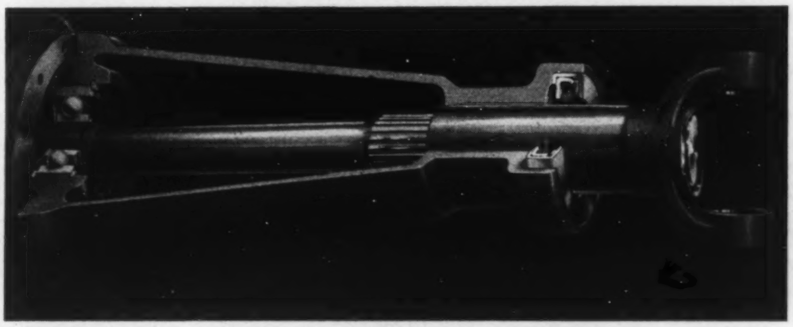

Figure 2

NATIONAL
OIL AND FLUID SEALS

NATIONAL MOTOR BEARING CO., INC.

General Offices: Redwood City, California
Plants: Redwood City and Los Angeles, California; Van Wert, Ohio

CALL IN A NATIONAL ENGINEER FOR RECOMMENDATIONS

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MILWAUKEE: 647 West Virginia St., Marquette 8-8986.
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Reprints from this or other Logbook pages are available for your files. Request them from our Redwood City, California, office

Enduro-TURNS IDEAS INTO REALITY!

SANITARY AND CORROSION-RESISTANT

. . . AND EASY TO MACHINE, TOO. These beverage dispensing valves had to be sanitary and resistant to corrosion. As you can see, there was plenty of machining involved, too. That's why Republic ENDURO Stainless Steel—Type 303—was selected in cold drawn bar form. In addition to sanitation and corrosion-resistance, it provided the close tolerances, accuracy of section, uniform soundness, fine surface finish and machinability which combine to keep down unit costs and reject losses. Don't worry about workability when you design with ENDURO. You can obtain up to 91% of the machinability of standard Bessemer Screw Stock (B-1112) with certain types of free-machining stainless steel.

A HARD-WORKING METAL ...BUT NOT HARD TO WORK WITH

When you're looking for a versatile material that works hard at doing many things well—but which can be fabricated satisfactorily and economically by all modern methods—think *FIRST* of Republic ENDURO Stainless Steel.

Here's a material you can use in a multitude of ways—to turn your ideas into reality. Use it for decorative purposes—or for functional needs. It has unusual beauty—that lasts indefinitely. It is outstanding in the battle against rust, corrosion and oxidation. Its high strength—maintained both at elevated and sub-zero temperatures—frequently permits valuable weight savings, without sacrifice of safety or life, through the use of thinner sections. Its freedom from metallic contamination and its remarkable ease of cleaning are well known wherever processing equipment is used. And, best of all, it usually outperforms and outlasts other materials—to cost less in the end. Where else can you find so many advantages in one material?

There are many types of ENDURO—each particularly suited to meet specific requirements. It is produced in a wide variety of finishes in sheet and strip form—in hot rolled or cold drawn bars—in plates—in pipe and tubing—in wire. It is available, too, in bolts, screws, nails, welding rod—practically every form you may require, including castings.

Why not get all the facts about ENDURO now and have them handy for your next job? Write us.

REPUBLIC STEEL CORPORATION
Alloy Steel Division • Massillon, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
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Enduro STAINLESS STEEL
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✓ ***Check ALL 12 advantages:*** • RUST AND CORROSION-RESISTANCE • HEAT-RESISTANCE • HIGH MELTING POINT • LOW COEFFICIENT OF EXPANSION • HIGH STRENGTH • GOOD DIMENSIONAL STABILITY • NO METALLIC CONTAMINATION • EASY TO CLEAN • EASY TO FABRICATE • EYE APPEAL • LONG LIFE • LOW END COST

STAINLESS STEEL
INDUSTRY EXHIBIT
101 PARK AVENUE
NEW YORK

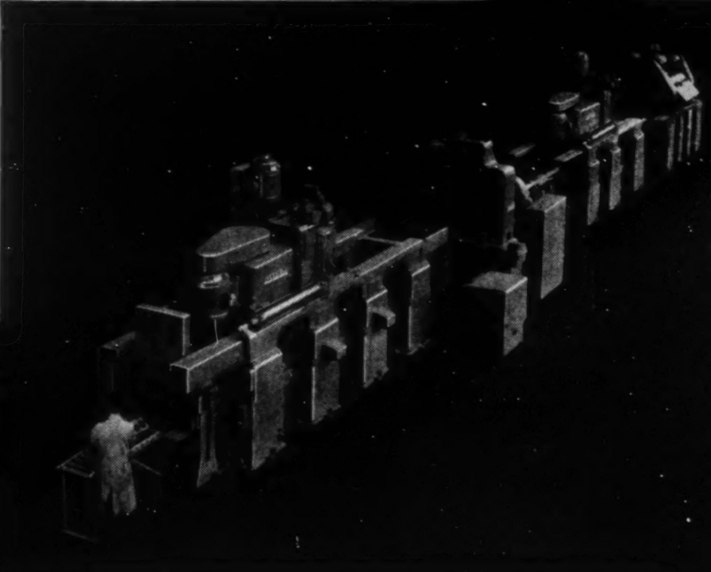
INGERSOLL PROCESS MACHINES
For Reducing the MAN HOURS per piece

Another COST-CUTTING Application of VICKERS HYDRAULICS

The two Ingersoll Process Machines illustrated here are being used for completely machining automobile cylinder blocks . . . they provide the extreme precision required and at the same time reduce the cost. It is significant that Ingersoll selected Vickers Hydraulic Controls for the many operations that can best be done with hydraulics.

Progression of the blocks through the machines is accomplished automatically, the time-saving transfer mechanisms being hydraulically actuated. Hydraulic circuits of the individual units provide for correct sequential positioning, clamping, traversing, feeding and returning. Interlocks assure accurate positioning, secure clamping and removal of interfering transfer members before cutting operations begin . . . also clearance of all cutters before transfer to next station can take place. Objectionable deflection is prevented by limiting the clamping pressure.

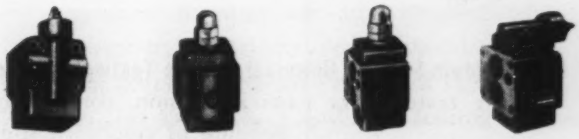
Get in touch with the nearest Vickers Application Engineering Office for information on how Vickers Hydraulics can improve your products.



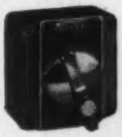
Ingersoll 9-Station Process Machine has Vickers Hydraulic Controls to help secure extreme precision in cylinder blocks at lowest cost.

Ingersoll 11-Station Process Machine receives cylinder blocks from machine at right and similarly has Vickers Hydraulic Controls.

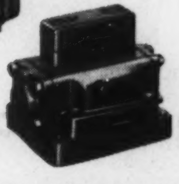
Representative VICKERS HYDRAULIC CONTROL UNITS USED ON INGERSOLL PROCESS MACHINES



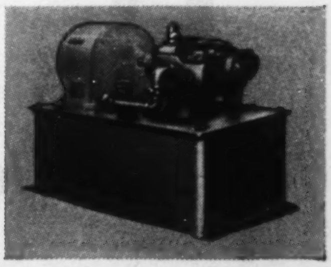
Pressure Controls, Bulletin 45-34a



Flow Control Valve, Bulletin 45-35



4-Way Valve, Pilot Operated, Solenoid Controlled, Bulletin 48-27



Power Unit, Bulletin 46-43a

VICKERS Incorporated

DIVISION OF THE SPERRY CORPORATION

1430 OAKMAN BLVD. • DETROIT 32, MICHIGAN

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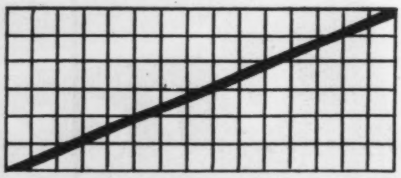
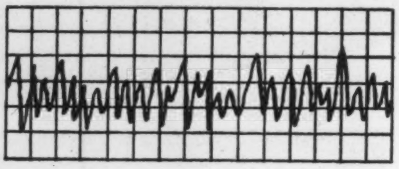
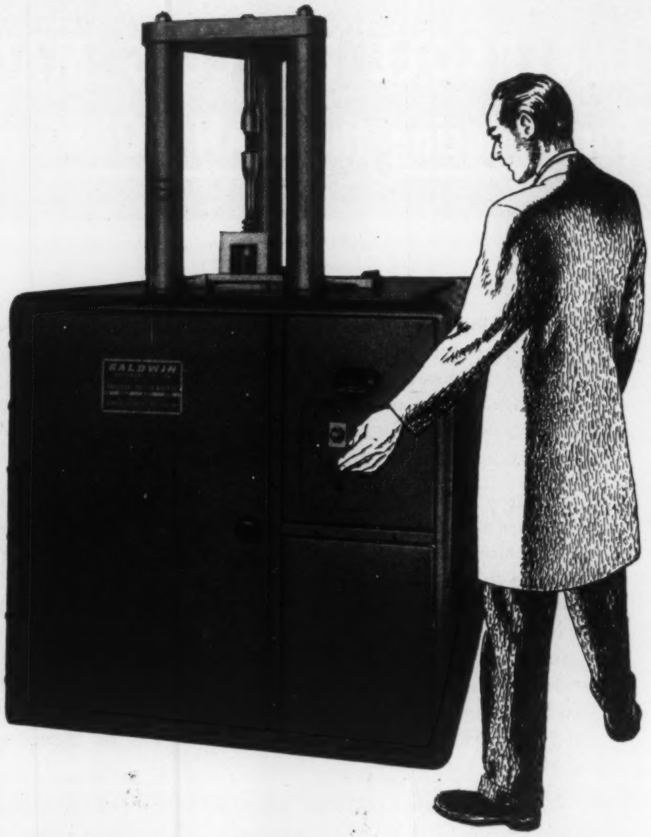
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Why DESIGN from loads

like this... 

When SERVICE means loads

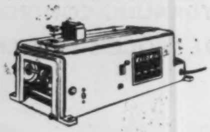
like this? 



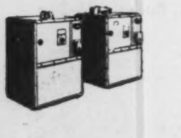
Designers often work under a handicap, because available test data covers only such properties as elastic limit, yield point, and ultimate strength. It leaves unanswered the biggest question of all—how *many* individual stressings can the material endure?

Today this *endurance* can be as accurately determined as the other physical properties, under conditions that simulate actual service conditions so closely that the results provide an accurate forecast of performance in the field. Here are some of the items in the Baldwin line of fatigue testing equipment.

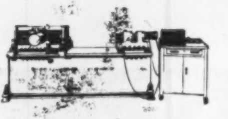
Baldwin-Sonntag SF-2 Fatigue Testing Machine. Small, light motor-driven unit for bench mounting for testing sheet materials in flexure. Adjustable alternating force up to 20 lbs.



Baldwin-Sonntag Universal Fatigue Testing Machines. For testing materials or parts in tension, compression, torsion, bending or combined stresses. Maximum force—SF-01-U, 200 lbs.; SF-1-U, 2000 lbs.

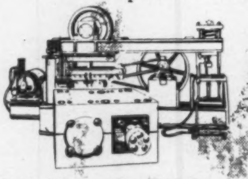


Baldwin-Sonntag SF-20-U Universal Fatigue Testing Machine. The most versatile machine currently available. Maximum force 20,000 lbs.—48-inch distance between platens—large permissible amplitude.



R. R. Moore High Speed Rotating Beam Fatigue Testing Machine. A new improved model, with greatly expanded testing capacity. Variable speed, automatic cut-off, cycle counter. Specimen can be loaded to 200 inch-pounds. Rated at 10,000 r.p.m.

Other Baldwin Fatigue Testing Equipment. The Baldwin line includes a number of special fatigue testing machines, such as the Lazan Oscillator, the Rolling Load Fatigue Machine, the BF Fatigue Machine, and others. If you have any special problems, ask about this special equipment.

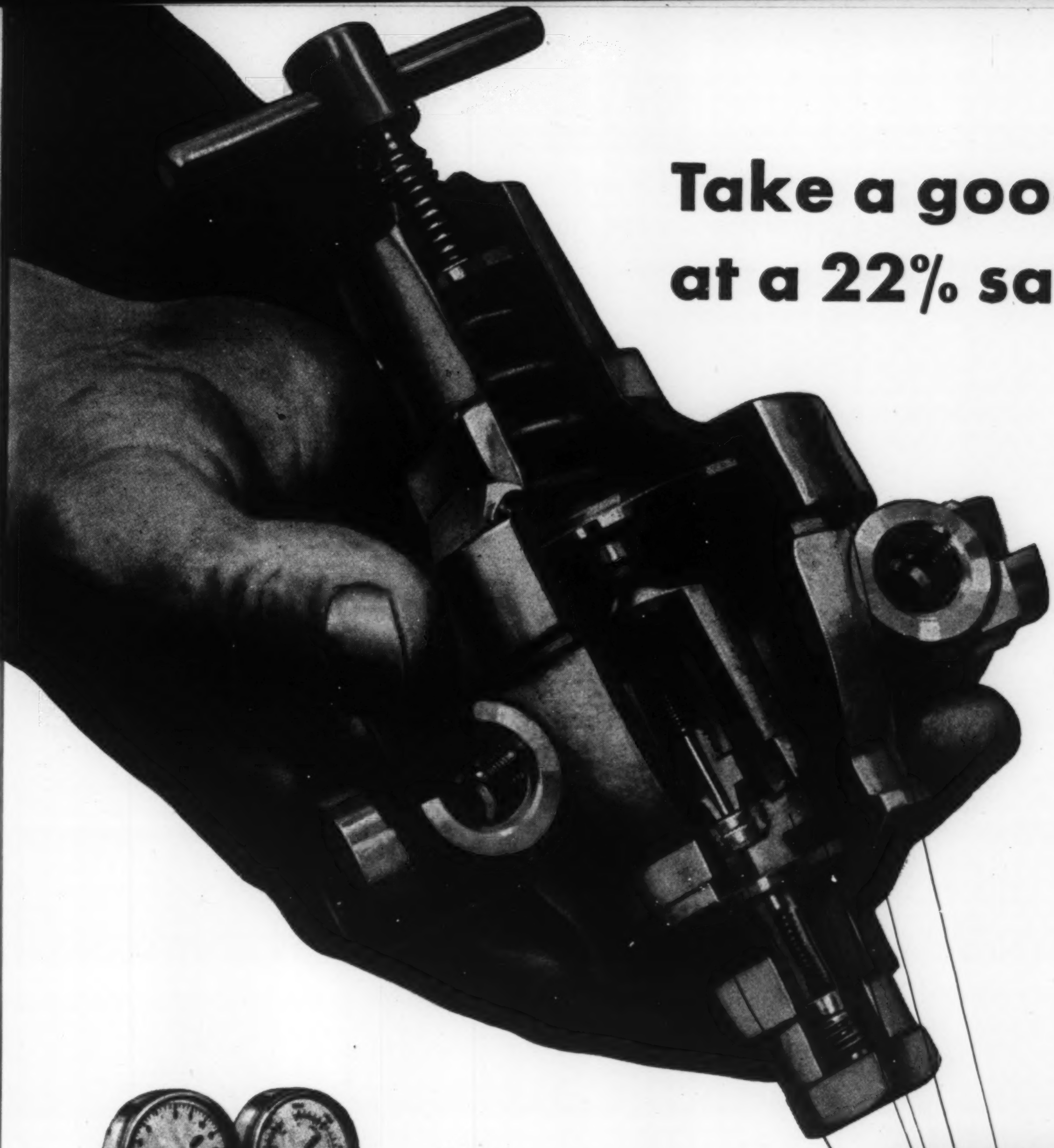


Ask For Technical Literature. Informative, illustrated bulletins on various items of Baldwin Testing Equipment have been prepared, and are available on request. Just designate what machine you are interested in, or the type of testing you want to do.

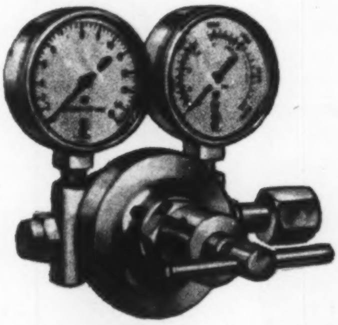
The Baldwin Locomotive Works, Philadelphia 42, Pa., U. S. A. Offices: Boston, New York, Philadelphia, Houston, St. Louis, Chicago, Cleveland, Pittsburgh, San Francisco, Seattle, Washington. In Canada: Peacock Brothers, Ltd., Montreal, Quebec.

BLW THE BALDWIN GROUP

testing headquarters ▶ **BALDWIN**



Take a good look at a 22% saving



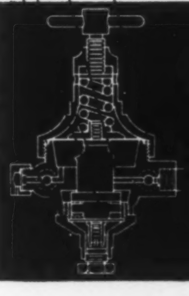
Double Gauge Oxygen Welding and Cutting Regulator, made by John Nageldinger & Son, Inc., New York, "Manufacturers of apparatus for the regulating and control of compressed gases since 1880." The cutaway illustration of the regulator is full-scale. All seals in the body are metal-to-metal, no gaskets being used. All parts, excepting the steel spring and nylon valve seat, are copper and copper alloys made by The American Brass Company.

HIGH GAS PRESSURES and sand castings just don't get along together. In fact, when test stand rejects on this job ran as high as 30% at several thousand pounds pressure, something had to be done about it . . . for not only the castings, but all machining operations were a total loss.

The manufacturer consulted The American Brass Company. Dies were made with a few slight changes in design and Anaconda Die Pressed Forgings, made of extruded rod, were supplied as illustrated here and on the following page.

Good news followed quickly: "Leakers" became a thing of the past, for these twice-wrought, dense-grained forgings are gas, air and water-tight. Rejects during machining dropped from an average of 18% to less than 1%. Combined tooling and machining costs were cut in half!

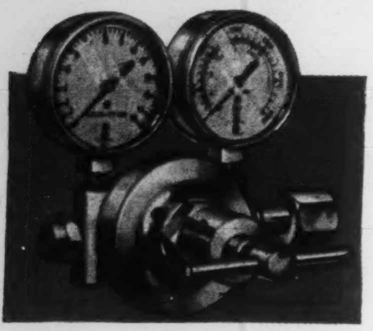
In this instance, the switch to Anaconda Die Pressed Forgings resulted in a net saving of 22%—with rejects and costs *down* . . . dependability and profits *up*.



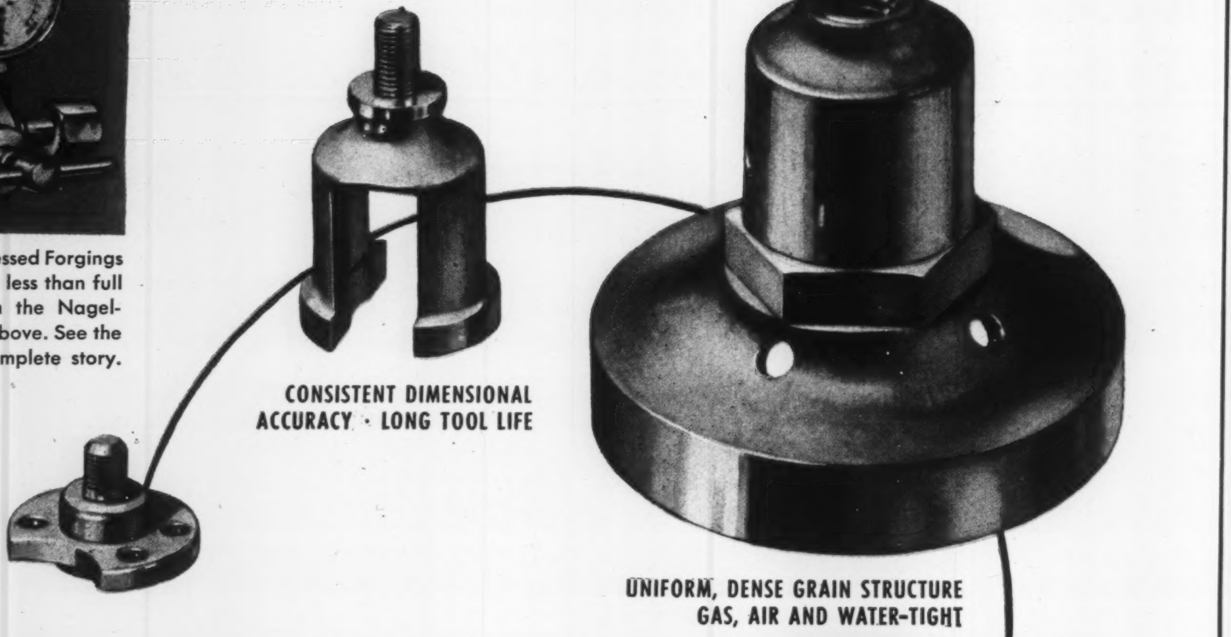
ANACONDA
DIE PRESSED
FORGINGS

THE AMERICAN BRASS COMPANY, General Offices: Waterbury 88, Connecticut

Perhaps similar savings could be made on your product . . . ▶



The five Anaconda Die Pressed Forgings illustrated here in slightly less than full scale are being used in the Nageldinger Regulator shown above. See the previous page for the complete story.



CONSISTENT DIMENSIONAL ACCURACY · LONG TOOL LIFE
UNIFORM, DENSE GRAIN STRUCTURE
GAS, AIR AND WATER-TIGHT

Don't be misled by their good looks!

Of course they're handsome, but make no mistake—these die pressed forgings are huskies throughout... solid, dense-grained working metal, with twice the strength of ordinary sand castings.

They're easy to machine, too—and more uniform than peas in a pod. Often it's simply a matter of drilling and tapping a few holes, threading a boss, or machining a mating fit—and they're ready for assembly.

If the production of unusual shapes is taking too big a bite out of your profits, send us a drawing, pattern or sample part, together with functional data. There's a very good chance that we'll be able to help you... we've done it hundreds of times for others. For general information on Anaconda Die Pressed Forgings, write for Publication B-9.

48122

THE AMERICAN BRASS COMPANY
General Offices: Waterbury 88, Connecticut
Subsidiary of Anaconda Copper Mining Company
In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

SMOOTH TEXTURE—
LOWER FINISHING COSTS

Anaconda
DIE PRESSED FORGINGS

AVAILABLE IN COPPER, BRASS, BRONZE AND SPECIAL COPPER ALLOYS

WHAT'S YOUR *Size* *please*

THERE'S A

FORMETAL SPACER TUBE *to fit*

● We aren't boasting! Whether you call them spacer tubes... ferrules... sleeves... or butted tubes—Formetal makes more of them than anyone else in the world... and the reason is simple. Because of our production, we make them better for less money than you can in your own plant.

Here's why you make a real savings when you buy Formetal Spacer Tubes. First, they are economical... cost less than welded or seamless tubing or pipe. Second, they are made to your specified dimensions (I.D.—O.D. and length) so they come to you *ready to use*. Third, they save you cutting off and burring operations, leaving your machinery open for other production. Fourth, they eliminate waste of material on your part, and save you handling time.

In addition, they can be produced from the exact metal or alloy you specify—with special seams, slots, or cut-outs, plain or plated. Hundreds of stock dies available for your job mean better prices and speedier delivery, too! We're really geared to save you money... so why not give us a chance to quote. If you'll send blueprints and specifications, we'll guarantee a prompt reply!

● MANUFACTURERS OF *Superformed* BUSHINGS AND BEARINGS

FORMETAL

NATIONAL FORMETAL COMPANY, INC.

ESTABLISHED 1919

Manufacturers of "Superformed" Bushings and Bearings... and Spacer Tubes

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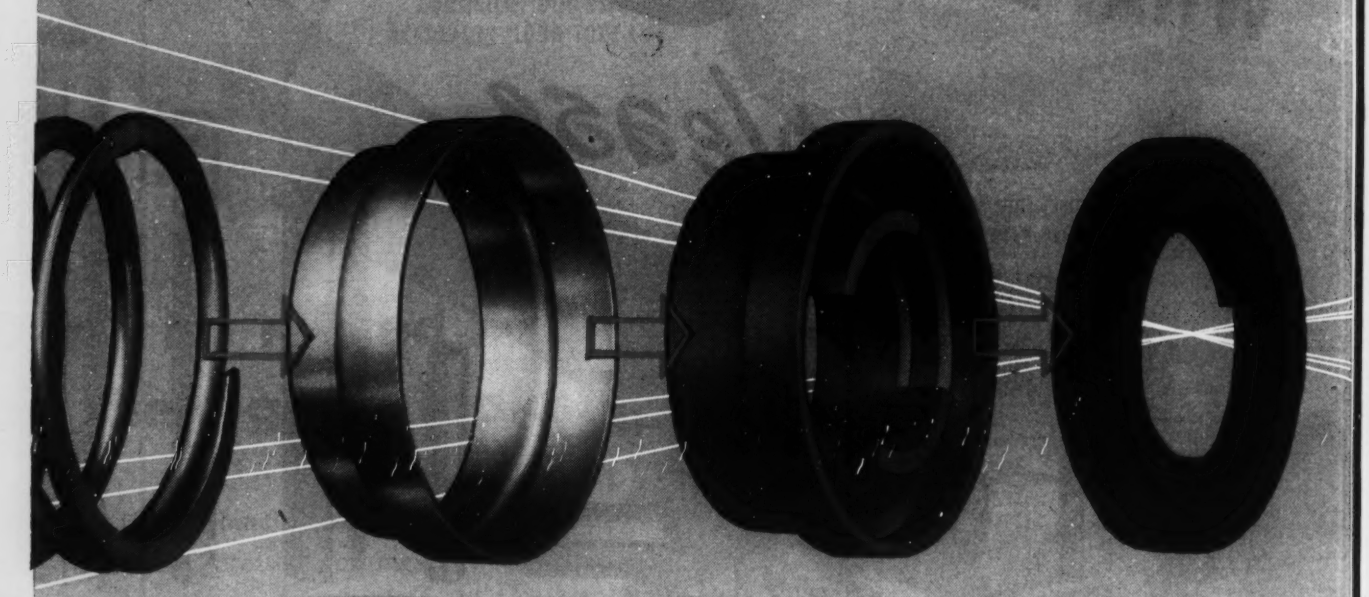
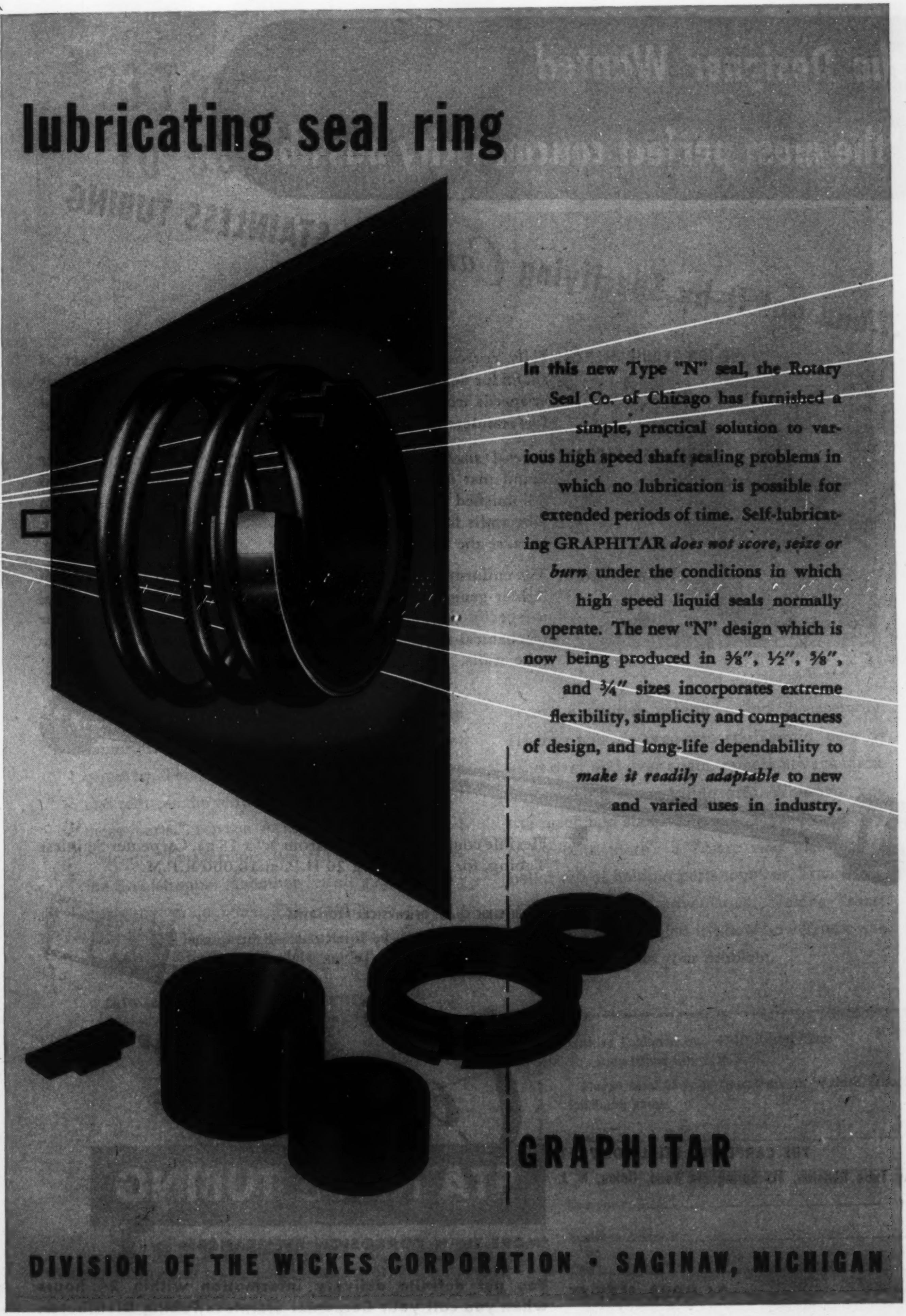
GRAPHITAR self-
(CARBON-GRAPHITE)
# ideal for new type ROTARY SEAL



GRAPHITAR is finding its way into many new industries, with scores of new uses because of its many unique and valuable characteristics. Graphitar is chemically inert, *is practically unaffected by high temperatures and is self lubricating.* While it is extremely light weight, it is mechanically strong. It is available in many different grades to meet particular specifications and working conditions. It can be molded into seals, bearings, rings and other parts that *can be ground to tolerances as close as .0005"* in small sizes. Our engineers will be glad to study your sketches and perhaps suggest how Graphitar will improve the efficiency of your operations. Ask for 44-page Graphitar catalog.

THE UNITED STATES GRAPHITE COMPANY



lubricating seal ring

In this new Type "N" seal, the Rotary Seal Co. of Chicago has furnished a simple, practical solution to various high speed shaft sealing problems in which no lubrication is possible for extended periods of time. Self-lubricating GRAPHITAR *does not score, seize or burn* under the conditions in which high speed liquid seals normally operate. The new "N" design which is now being produced in 3/8", 1/2", 5/8", and 3/4" sizes incorporates extreme flexibility, simplicity and compactness of design, and long-life dependability to *make it readily adaptable* to new and varied uses in industry.

GRAPHITAR

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

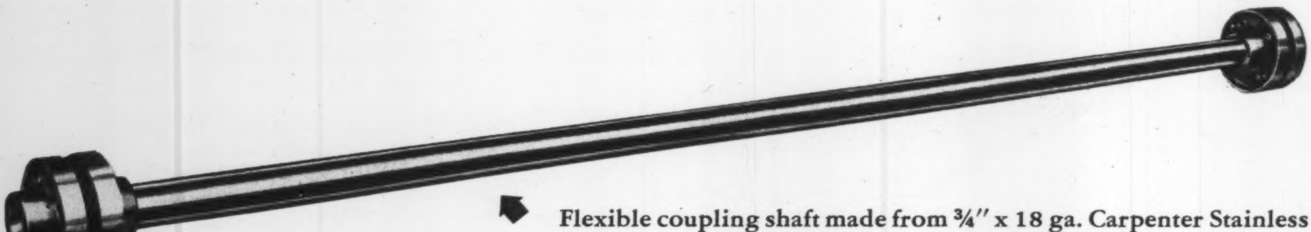
the Designer Wanted
"the most perfect concentricity possible"

...and got it by Specifying *Carpenter* STAINLESS TUBING

THE JOB REQUIREMENTS: Fully corrosion-resistant tubes (for weight saving) to act as shafts for flexible couplings. Because shafts transmit heavy loads at speeds from 3,600 to 10,000 R.P.M., the specification called for Stainless Tubing with ***the most perfect concentricity possible.***

THE COST FACTOR: Several sizes of tubing were required, and the manufacturer found that in every case Carpenter Stainless Tubing, standard full-finished grade, was ideal for the job. Exceptionally uniform tube walls for this precision job were secured at no extra cost, because the specification called for *Carpenter* Stainless Tubing.

YOUR SAVINGS: The uniform walls of Carpenter Stainless Tubing permit the use of lighter gauges without sacrifice of strength. So it is economical to specify *Carpenter* on your orders—even on jobs where your mechanical requirements do not call for exceptionally uniform tube walls.



Flexible coupling shaft made from ¾" x 18 ga. Carpenter Stainless Tubing, for transmitting 20 H.P. at 10,000 R.P.M.

USEFUL SLIDE CHART OF PHYSICAL PROPERTIES ...

A note on your company letterhead will bring you the Carpenter Stainless Tubing Slide Chart. Send for your copy today.

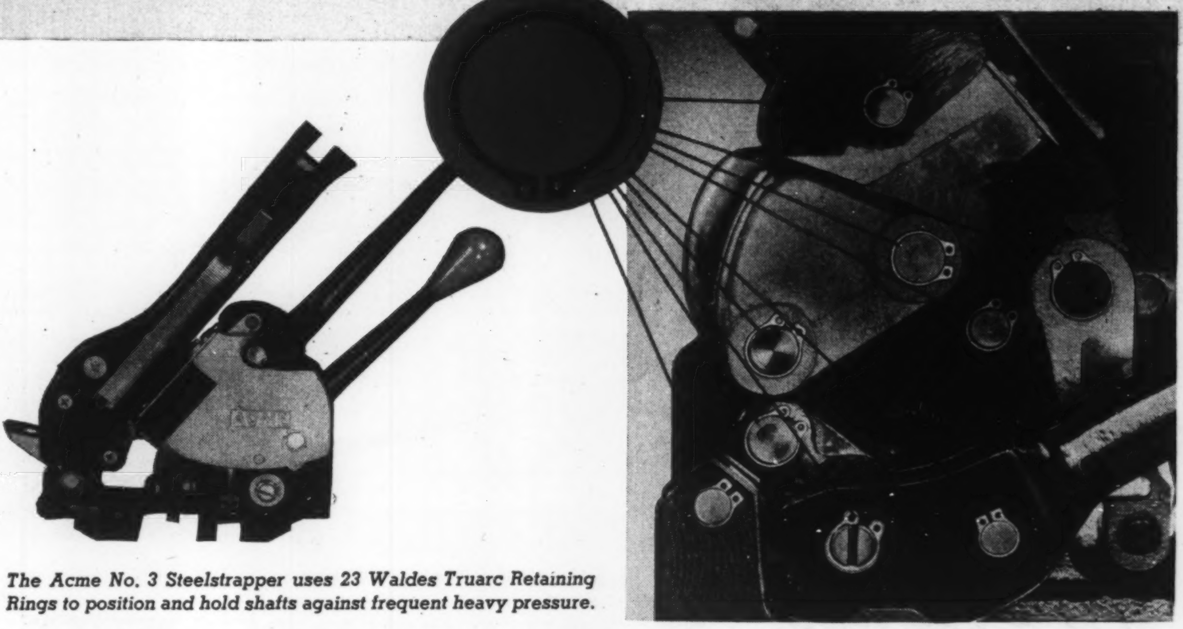
Carpenter
STAINLESS TUBING

"MORE THAN CORROSION RESISTANCE"

THE CARPENTER STEEL COMPANY
Alloy Tube Division, 115 Springfield Road, Union, N. J.

24-HOUR SERVICE **You get definite delivery information within 24 hours when you call your Carpenter Stainless Tubing Distributor.**

23 Truarc rings permit changeover to centerless grinding savings



The Acme No. 3 Steelstrapper uses 23 Waldes Truarc Retaining Rings to position and hold shafts against frequent heavy pressure.

"The use of Truarc Retaining Rings permits centerless grinding of pins instead of plunge-grinding. This eliminates the problem of taper and reduces the required tensional tolerances of these parts," reports Acme Steel Company of Chicago. "Furthermore, use of Truarc rings gives the Steelstrapper smoother lines by eliminating unsightly projections. This results in a more streamlined housing, a definite sales advantage."

Making repairs is much easier too, because Truarc simplifies assembly and disassembly. Truarc rings are precision engineered, may be used over and over again, remain always circular to give a never-failing grip. Wherever you use machined shoulders, nuts, bolts, snap rings, cotter pins—there's a Truarc ring that does a better job of holding parts together. Truarc cuts costs, adds sales advantages. Waldes Truarc engineers will be glad to show how Truarc can help you. Send us your problem.

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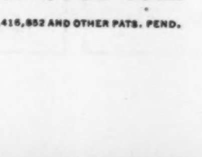


WALDES

TRUARC

REG. U. S. PAT. OFF.

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS ARE PROTECTED BY U. S. PATS. 2,302,948; 2,026,454; 2,416,852 AND OTHER PATS. PEND.

MD-3

Waldes Kohinoor, Inc., 47-10 Austel Place
Long Island City 1, N. Y.

Please send 28-page Data Book on Waldes Truarc Retaining Rings.

Name______________________________

Title______________________________

Company____________________________

Business Address_______________________

City_______________Zone______State________ ★

LET "X" = AN UNKNOWN QUANTITY

When you draw the familiar "X" symbol to indicate a valve in plans for any product involving fluid control, *never* let it represent a valve of uncertain performance.

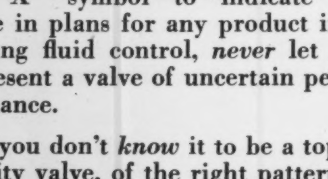
If you don't *know* it to be a top-quality valve, of the right pattern, properly placed in the assembly, you're inviting trouble that may give your whole product a "black eye". Second-rate valves only *seem* more economical, for the few cents saved in initial cost is likely to be paid out many times over in excessive servicing costs.

You can be sure of trouble-free performance when the "X" represents a Jenkins Valve. There's no better valve made. And, proper selection and application for faultless service is assured because you command the knowledge of Jenkins Engineers.

Equally important, your customers will be sure they are getting trouble-free valves when they see the familiar Jenkins Diamond trade mark. Your customers *know* Jenkins Valves . . . know them as tops in quality. You benefit from Jenkins leadership in advertising and consistent leadership in quality for 83 years. To your prospects Jenkins Valves will signify thoroughgoing quality construction throughout your product.

When planning new products, or redesigning present equipment that requires valves, — give your product, and its purchasers, the *extra value* of Jenkins Valves . . . *it costs no more.*

Jenkins Bros., 80 White Street, New York 13; Bridgeport, Conn.; Atlanta; Boston; Philadelphia; Chicago; San Francisco. Jenkins Bros., Ltd., Montreal.



GET JENKINS DESIGNERS' KIT. A handy file of valve information needed by product development men . . . helps answer the question — "Which type of valve where for best performance?" Mail the coupon.

JENKINS BROS., 80 White St., New York 13

Please send me the Jenkins Designers' Kit.

Name...

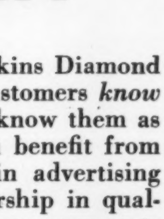
Company...

Address...

LOOK FOR THIS DIAMOND MARK

SINCE 1864

JENKINS VALVES



Types, Sizes, Pressures, Metals for Every Need

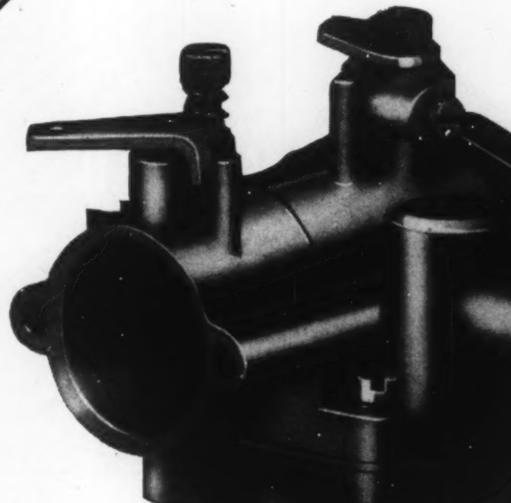
NOW! FOR 5 HORSEPOWER ENGINES OR UNDER

ZENITH

Leading Manufacturer of Carburetors for Tough Jobs . . .

Presents the

ZENITH "WORKHORSE"



Everything else being equal, you can build a better carburetor for hard usage if you have more than imagination to go by. Zenith *knows* the problems! Over a forty year span, Zenith* has put more heavy-duty carburetors on trucks, tractors, bulldozers and other hard-working equipment than any other manufacturer.

That's why, in presenting the new Series 10 "Workhorse" carburetor for low horsepower engines, Zenith is absolutely certain of its durability and performance. Its high angularity design makes it function equally well on level or hillside operation, and its simplicity eliminates many mounting problems.

Designers and manufacturers are invited to draw on the specialized carburetion experience that Zenith has acquired over the years. Get full information on the "Workhorse" now by writing the factory direct. *REG. U.S. PAT. OFF.

ZENITH CARBURETOR DIVISION of Bendix AVIATION CORPORATION

696 HART AVENUE • DETROIT 14, MICHIGAN

A pleasant note for tubular needs

Like to add a pleasant note to your present tubular applications—a note of better design, faster production, lower costs or higher quality?

If you would, better sound out Bundyweld* Tubing!

Made of steel, Monel, or nickel by a patented process, leakproof, vibration-resistant Bundyweld is manufactured to close tolerances always. Strong yet ductile, it bends without collapsing or weakening structurally, and can be machined or fabricated easily and readily.

Tubular parts for toys, refrigeration, radiant heating, television, automobiles, machine tools, ranges . . . these are only a few of the fields that find Bundyweld ideal for their tubular needs.

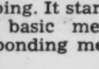
If you have a tubular design or production problem, chances are that this miracle tubing of industry can strike a responsive chord in its solution. Why not give it a try? Contact your nearest Bundy representative listed below, or write direct to: *Bundy Tubing Company, Detroit 14, Michigan.*

BUNDY TUBING

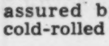
ENGINEERED TO YOUR EXPECTATIONS

* REG. U.S. PAT. OFF. ®

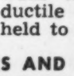
WHY BUNDYWELD IS BETTER TUBING



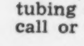
1 Bundyweld Tubing, made by a patented process, is entirely different from any other tubing. It starts as a single strip of basic metal, coated with a bonding metal.



2 This strip is continuously rolled twice laterally into tubular form. Walls of uniform thickness and concentricity are assured by close-tolerance, cold-rolled strip.



3 Next, a heating process fuses bonding metal to basic metal. Cooled, the double walls have become a strong ductile tube, free from scale, held to close dimensions.



4 Bundyweld comes in standard sizes, up to ⅝" O.D., in steel (copper or tin coated), Monel or nickel. For tubing of other sizes or metals, call or write Bundy.

BUNDY TUBING DISTRIBUTORS AND REPRESENTATIVES

Cambridge 42, Mass.: Austin-Hastings Co., Inc., 226 Binney St. • ***Chattanooga 2, Tenn.:*** Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. ***Chicago 32, Ill.:*** Lapham-Hickey Co., 3333 W. 47th Place • ***Elizabeth, New Jersey:*** A. B. Murray Co., Inc., Post Office Box 476 • ***Philadelphia 3, Penn.:*** Rutan & Co., 404 Architects Bldg. • ***San Francisco 10, Calif.:*** Pacific Metals Co., Ltd., 3100 19th St. • ***Seattle 4, Wash.:*** Eagle Metals Co., 3628 E. Marginal Way • ***Toronto 5, Ontario, Canada:*** Alloy Metal Sales, Ltd., 881 Bay St.

BUNDYWELD NICKEL AND MONEL TUBING IS SOLD BY INTERNATIONAL NICKEL COMPANY DISTRIBUTORS IN PRINCIPAL CITIES.

more fastening-wise manufacturers call on Parker-Kalon

...BECAUSE THEY GET MUCH *more* THAN SELF-TAPPING SCREWS ALONE

more **"KNOW-HOW"** — P-K originated the Self-tapping Screw, has been the leader with new designs ever since.

more **"SHOW HOW"** — The P-K staff of Assembly Engineers advise designers and assembly supervisors how to make better assemblies, lower fastening costs, — have helped solve nearly a million application problems during 35 years of specialization on this type of fastener.

more **TYPES AND SIZES** — P-K makes *six* types of Self-tapping Screws, the only complete line. P-K advice is unbiased, fits the screw to the job, not the job to the screw.

more **EXACTING QUALITY CONTROL** —With an investment in laboratory testing and inspection equipment unsurpassed in the industry, P-K customers can depend on uncompromising quality.

more **PRODUCTION** — P-K is the world's leading manufacturer of Self-tapping Screws, offering a steady supply to fill any size orders.

more **TOP-RATED DISTRIBUTORS** — Everywhere throughout the U. S. and Canada, P-K Self-tapping Screws are available from leading distributors, ready to give you quick, complete service.

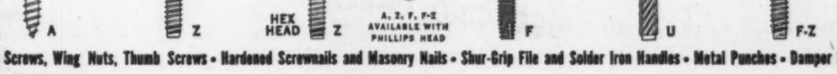
only **PARKER-KALON** offers all these *extras*. Make sure you get them. Whether your product is in the planning stage or in production, call in a P-K Assembly Engineer. If you prefer, mail assembly details for recommendations. You'll see why, as every user knows, when you buy Self-tapping Screws, *you're* O.K. with P-K! Parker-Kalon Corporation, 200 Varick St., New York 14, N. Y.

P-K®

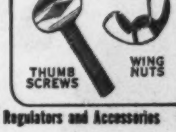
The Original

PARKER-KALON SELF-TAPPING SCREWS

FOR EVERY METAL AND PLASTIC ASSEMBLY



P-K Also Makes
Cold-forged



OTHER P-K PRODUCTS: Cold-Forged Socket Screws, Wing Nuts, Thumb Screws • Hardened Screwnails and Masonry Nails • Shur-Grip File and Solder Iron Handles • Metal Punches • Damper Regulators and Accessories

The Magic of SILICONE RUBBER

Specify Silicone Rubber on the Drawing Board to Solve High and Low Temperature Problems

Thousands of Silicone rubber parts are shipped daily to manufacturers who need a rubber capable of withstanding temperatures from a low of -160 to a high of more than 500° F. These parts, in many cases, have been designed to replace metal constructions in which limited thermal stability has been experienced.

Silicone rubber has most of the desirable characteristics of natural rubber in addition to special properties, and is suitable for dielectric applications. Also, this new rubber is resistant to permanent compression, prolonged weathering, lubricating oils and many chemicals.

Gaskets, diaphragms, grommets, seals, packings, tubing and other Silicone rubber fabrications are recommended for use in steam generators, gas cylinders, jet and conventional aircraft engines, electrical heating apparatus, electric motors, transformers, die casting machines, refrigeration and air conditioning equipment, and industrial ovens.

The Stalwart Rubber Company will fabricate Silicone rubber to your individual specifications. Modern engineering facilities and unerring production methods assure precision rubber products.

Complete laboratory facilities are available for the compounding of all types of special rubbers to meet either very limited or very broad applications, for developing new compounds to solve specific engineering problems, and for testing all types of rubbers to determine their suitability for various applications.

WRITE FOR
CATALOG TODAY.

Specify Stalwart — for Quality Custom Rubber Products

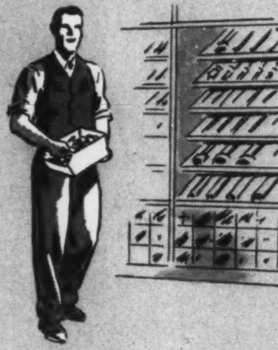
STALWART RUBBER CO.

3180 NORTHFIELD ROAD
BEDFORD, OHIO

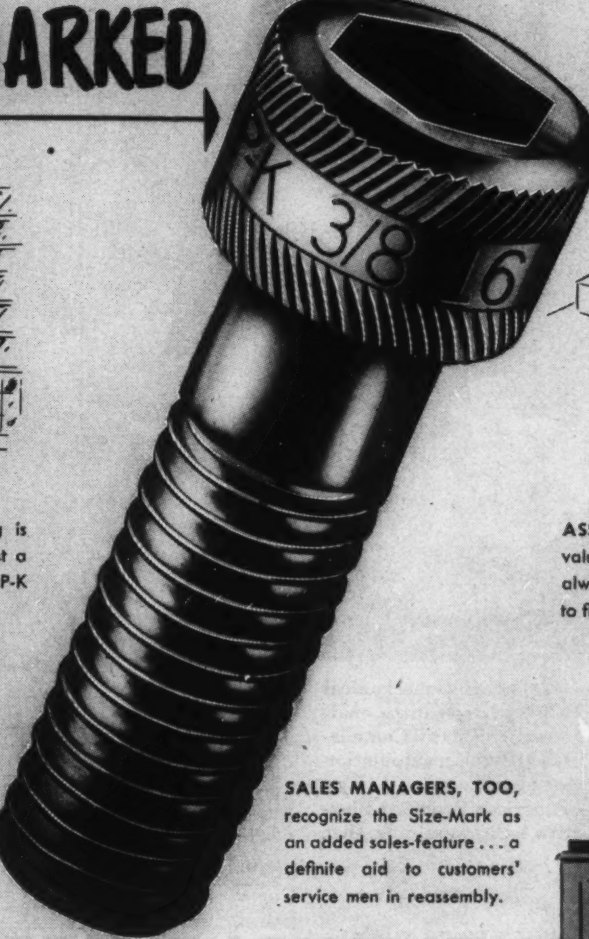
Here's what they say about P-K

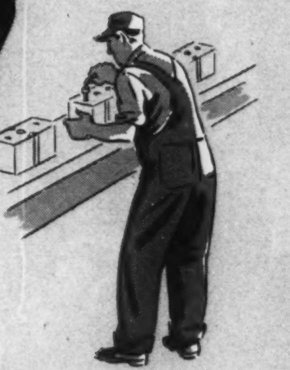
SIZE-MARKED

Socket Head Cap Screws



TOOL CRIB BOSSES say sorting is made easier, speeded up . . . just a quick glance at the head of any P-K Cap Screw reveals its size.





ASSEMBLY LINE OPERATORS report valuable time saved because sizes are always issued correctly . . . no time out to find out — job moves faster.

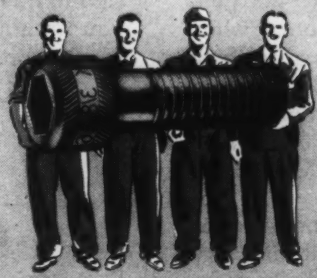
SALES MANAGERS, TOO, recognize the Size-Mark as an added sales-feature . . . a definite aid to customers' service men in reassembly.

NEW HELP agree sizes can be learned faster . . . also, the Size-Mark protects them from errors.

Plus . . . GEAR GRIP* . . . it simplifies work!

Gear Grip on Size-Marked Socket Head Cap Screws is a further aid to fast work . . . prevents slipping even when fingers are oily.

ONLY PARKER-KALON OFFERS BOTH Size-Mark and Gear Grip in Socket Head Cap Screws. See how they save time and trouble all along the line.



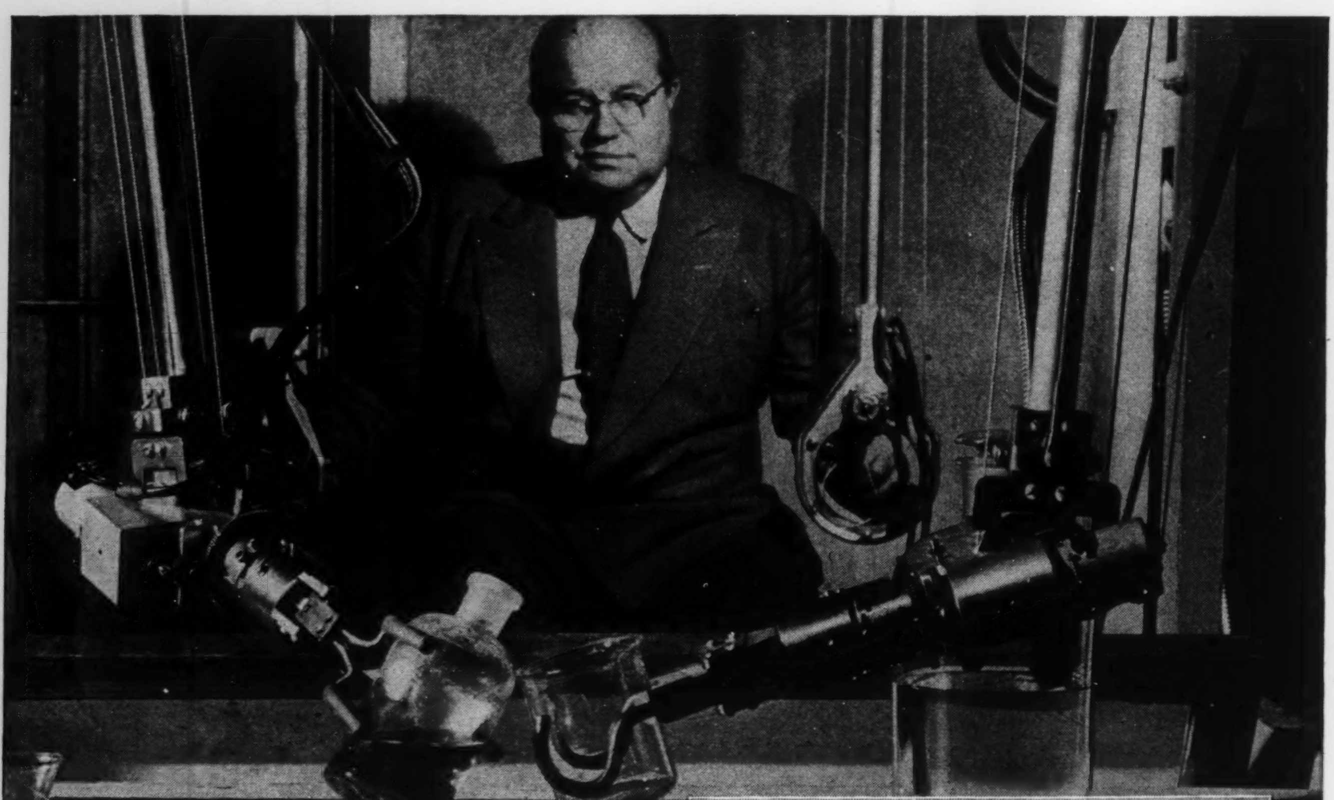
SEND FOR SAMPLES. Discover for yourself why P-K Socket Screws can put your product out front, assembly-wise and sales-wise. Parker-Kalon Corporation, 200 Varick Street, New York 14, New York.

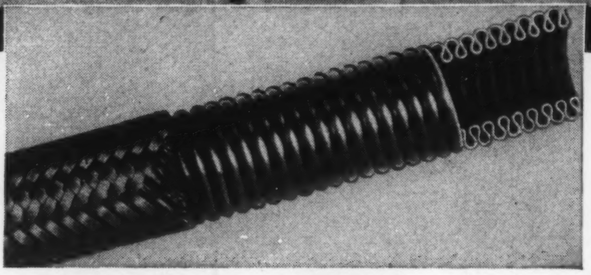
P-K Socket Screws are available for prompt delivery in every industrial area.

SEND FOR STOCK LIST NOW

PARKER-KALON *COLD-FORGED* SOCKET SCREWS

*U. S. DESIGN PAT. NO. 126,409 **SOLD ONLY THROUGH ACCREDITED DISTRIBUTORS**





Inventor, John Payne, operates the amazing mechanical hands that he and other General Electric scientists, engineers and craftsmen built for the Atomic Energy Commission. It is operated through a thick wall, the manipulation being guided with the help of mirrors.

At right, cut open view of the American Seamless Flexible Metal Hose, with its protective bronze braiding, that conveys actuating brake fluid.

AMERICAN FLEXIBLE METAL HOSE

Helps Probe Atomic Secrets

THIS IS THE WAY to handle lethal, radio-active materials you dare not touch!

These robot hands, with fingers as sure and gentle as a man's, infinitely more powerful when strength is needed, are operated through a thick lead wall. Small electric motors turn the hands at the will of the operator, while other motions are mechanical, with hydraulic force applied through ¼″ I.D. American Seamless Flexible Metal Tubing to operate the fingers.

In building this intricate machine the selection of indestructible and trouble-free materials was very important, since the parts themselves are liable to become contaminated and hence difficult to repair, adjust, or replace. For conveying the brake fluid that actuates the nimble steel fingers, our Type S-1, standard American Seamless Flexible Metal Tubing of bronze, was used. It is pressure-reinforced with bronze wire braid.

Whether your own problem is to convey steam, oil, water, other fluids, semi-solids or gases under varying conditions of pressure, temperature, vibration, misalignment, movement or restricted space, you may save time, money and experimentation by consulting American first. Special design to meet your own service requirements costs you nothing extra. Write for literature, and feel free to consult our Technical Department. 49287

ANACONDA
from mine to consumer

American
METAL HOSE

THE AMERICAN BRASS COMPANY
American Metal Hose Branch
General Offices: Waterbury 88, Connecticut
Subsidiary of Anaconda Copper Mining Company
Distributed in Canada by:
THE CANADIAN FAIRBANKS-MORSE COMPANY, LIMITED

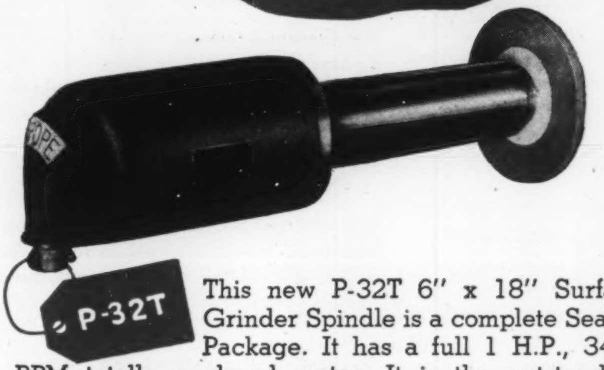
POPE
Sealed Package
SPINDLES

The Spindles pictured are among the most popular and widely used of the many Pope *Sealed Package* Spindles.

These Spindles assure you:

Continuous Production of High Quality
Cool Operation at High Speeds
Sealed Lubrication Performance

— no oiling or greasing, nothing to renew, replace or adjust throughout the entire life of the bearings.



This new P-32T 6" x 18" Surface Grinder Spindle is a complete Sealed Package. It has a full 1 H.P., 3450 RPM totally enclosed motor. It is the outstanding spindle for surface grinding. Ask for the Pope Sealed Package Spindle, *P-32T*.

This Pope Tool Grinder Spindle is equipped with 1 H. P., 3450 RPM totally enclosed motor; for grinding wheels up to 8" O. D., ¾" face, 1¼" hole. *Sealed* Lubrication. Ask for *P-1004*.

This Pope Heavy Duty Spindle with totally enclosed fan cooled motor is ideal for surface grinding. It can be mounted on planers and boring mills. It comes in a variety of sizes from ¾ to 20 H.P. and from 900 to 3600 RPM. *Sealed* Lubrication. Ask for *P-2500*.

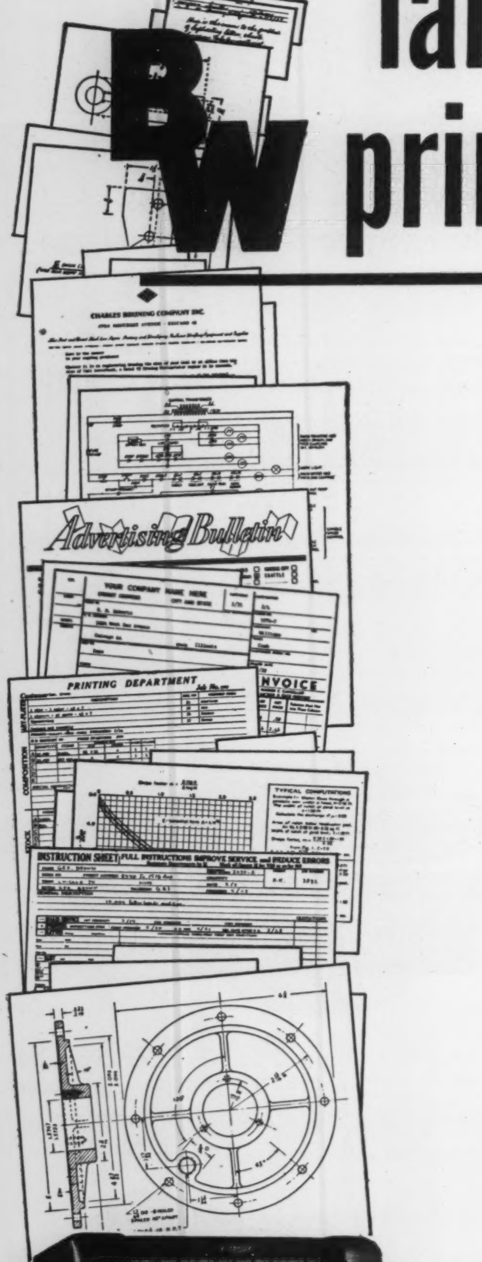
This Pope Heavy Duty Vee Belt Driven Wheel Head Spindle takes grinding wheels from 6" to 36" diameter. Maximum speed 4000 RPM. Ask for *P-666*.

No.58

POPE

POPE MACHINERY CORPORATION
ESTABLISHED 1920
261 RIVER STREET • HAVERHILL, MASSACHUSETTS
BUILDERS OF PRECISION SPINDLES

BW large volume print production



Never before has a single Whiteprinter been able to offer you all the advantages found in this new Volumatic Model 93. It is the last word in large volume production of high quality direct positive BW prints. Advance models of this machine have already proved that it can reduce reproduction costs . . . by faster production, less wastage, lower maintenance, simpler operation.

It has countless uses. The Volumatic, like other Bruning Whiteprinters, produces sharp, highly legible copies of engineering drawings and documents . . . in fact anything that is printed, drawn, written, or typed on a translucent medium. Its uses increase daily as more and more business and industries turn to Bruning Whiteprinters to eliminate the costly practice of transcribing documents, forms and records of all kinds.

It is extremely versatile. The Volumatic Model 93 takes cut sheets or roll stock with equal facility. It produces sharp BW prints from post card size up to 42-inches wide and unlimited length. You can have light, medium or card weight prints . . . prints on tinted stocks . . . prints on film or cloth . . . prints with colored lines.

Any one can operate it. The operation of the BW Model 93 has been simplified to the point where a girl can learn to operate it in less than an hour.

Faster operation. The new Volumatic produces BW prints up to 105 square feet a minute *at normal operating speeds.* The prints are delivered dry and ready for instant use, neatly stacked at the front or rear of the machine as desired.

Completely odorless. The developing solutions used to produce sharp clear Bruning Whiteprints are harmless and odorless. The machine does not require outside ventilation or exhaust ducts. It can be installed anywhere without offense.

It is mobile. There are no pipe or plumbing connections to tie this machine to one spot. It is built on casters so that it can be moved easily to efficient locations.

Uniform quality control. BW Model 93 automatically and instantaneously coordinates developing and printing speeds. Changes in printing speed never result in over-or-under developed prints. A further safeguard to quality is Bruning's built-in constant voltage transformer which assures uniform operation of the machine although line voltages may vary from 190 to 250 volts AC.

***Send today* for full information.**

Let us send you a complete file of literature describing the new BW Model 93 and the BW mediums you can use with it. See for yourself the extreme versatility, economy and speed of this machine. There is no obligation.

BRUNING WHITEPRINTER 93

VOLUMATIC MODEL

Other Bruning products you should know about—
Drafting Machines • Sensitized Papers & Cloth • Tracing Papers • Erasing Machines • Drafting Room Furniture • Slide Rules • Surveying Instruments • and many other products.

Charles Bruning Company, Inc.

4726-32 West Montrose Avenue, Chicago 41, Ill.

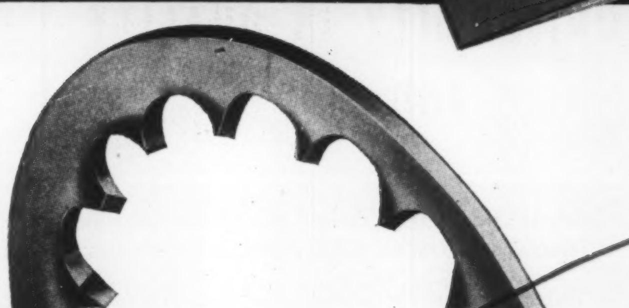
New York • Chicago • Los Angeles • and 11 other cities

DISCOVER
THE SAVINGS
IN *specially designed*
LOCKING POWER

WHY
HOW
WHERE
SHAKEPROOF
LOCK WASHERS

WRITE FOR THIS FREE BOOK!

Investigate the cost-saving and performance-improving advantages of engineered Shakeproof Lock Washers!



Look-alikes don't always work alike. For example, the Internal Type Shakeproof Lock Washer shown above has a standard rim and standard number of teeth for use under standard ½" nuts. The Internal Lock Washer at left is a special *thin-rimmed* washer with *more* locking teeth for specific use under ½" conduit nuts in electrical assemblies.

Knowing when and how to apply the standard and special types and sizes of Shakeproof Lock Washers will mean increased fastening efficiency and lower assembly costs to you. And, that's what this new book on Shakeproof Lock Washers is for . . . with illustrations and typical applications of all the Shakeproof Lock Washer types, an explanation of the locking principle and handy size data! See what Shakeproof Lock Washers can do in your specific application. Write for your free copy today!

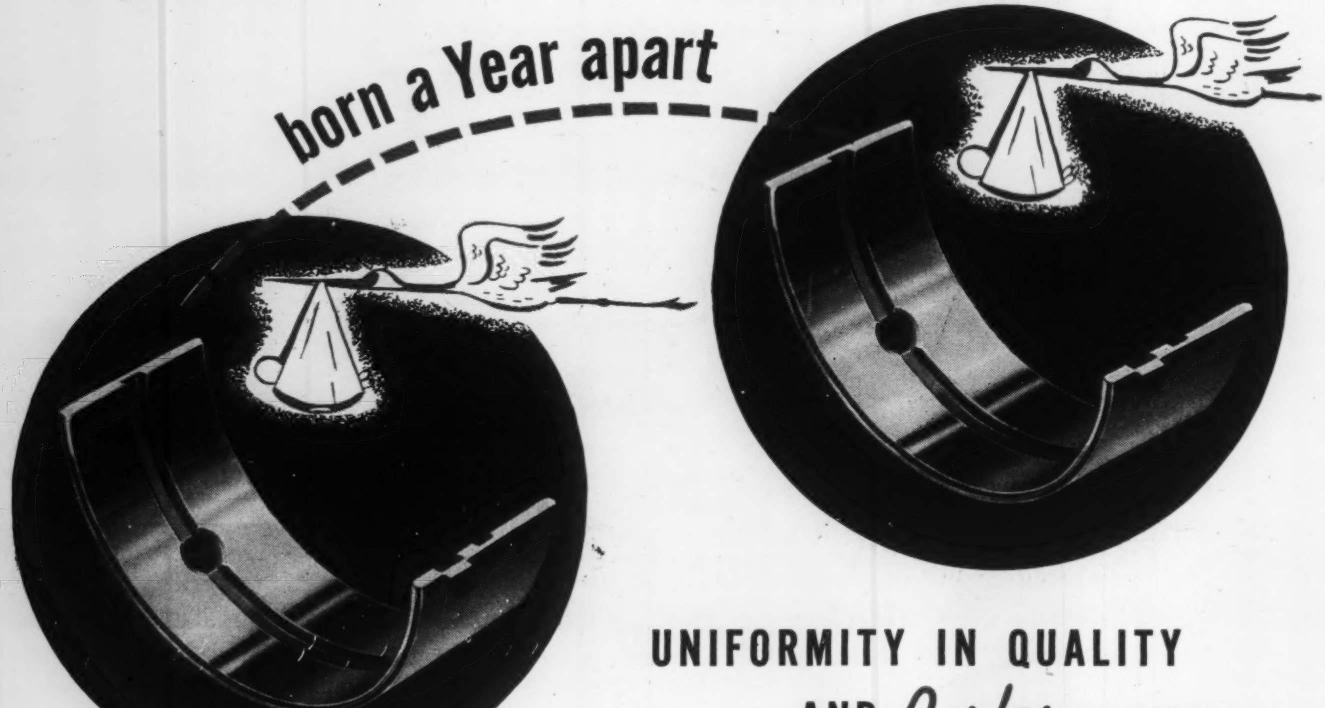
SHAKEPROOF inc., Division of Illinois Tool Works, 2501 North Keeler Avenue, Chicago 39, Illinois. In Canada: Canada Illinois Tools, Ltd., Toronto, Ontario.

FASTENING HEADQUARTERS
TRADE MARK

Shakeproof
LOCK WASHERS

IDENTICAL TWINS

IDENTICAL TWINS

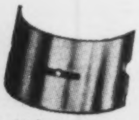


UNIFORMITY IN QUALITY AND *Performance*

Little wonder that the two sintered copper-lead main bearings shown above are even *more* alike than two peas in a pod!

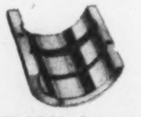
Each went through a total of 20 precise manufacturing operations from the sintered strip to the final over-plating. In processing they received a total of 35 setup and inspection measurement checks. Eighteen additional checks included analysis, temperature controls, special and visual inspections.

These "twins" aren't special favorites in the Federal-Mogul bearing family, either. We pamper 'em all! With our specialized six-plant organization we can produce large or small runs to your specifications. Engineering consultation available, without obligation.



HIGH SPEED, high temperature, automotive type bearings available in many combinations.

SPEED & LOAD bearings for pumps, compressors, industrial electric motors and similar uses.



HEAVY LOAD for big Diesels, power plants, etc.—bearings up to 27½" O.D., steel and bronze back.

BRONZE PARTS in many shapes, sizes; thrust washers, bushings; for many types of applications.

1899 • 50 YEARS' CONTINUOUS BEARING EXPERIENCE • 1949

FEDERAL-MOGUL

FEDERAL-MOGUL CORPORATION FEDERAL Mogul **11045 SHOEMAKER, DETROIT 13, MICH.**

Silent SLEEVE BEARINGS

IT'S ALL FOR THE GOOD OF SIRVIS . . .

THE BOIL TEST

Boiling would be rugged treatment for any steer. But, for Sirvis steer*hide* it's a must. The boil test, which is more severe than either dry heat or hot oil tests, determines heat resistance, measured by shrinkage. Because of Sirvis tanning processes, shrinkage under the boil test is usually less than 1%. Sirvis' reaction to the test is demonstrated by two pieces of buff grain steerhide, identical in quality and dimensions. After boiling in the same container for thirty minutes, one piece, an ordinary vegetable tanned leather, was hard, curled and shrunken, as shown in the photograph. The Sirvis chrome retanned piece shrank only 0.7% . . . retained its natural flexibility, strength and texture . . . and its resistance to heat was thereby accurately determined.

This is just one of the many laboratory controlled tests to which Sirvis leathers are subjected . . . so that you may be assured of top quality in packings, boots, gaskets, diaphragms and other mechanical leather products. Because of extreme care in designing, excellence of materials, and constant checks in production, Sirvis mechanical leathers are outstanding in dependability.

- *For detailed information about Sirvis products, write for the free Chicago Rawhide catalog.*

OTHER C/R PRODUCTS
PERFECT
Oil Seals
SIRVENE
Synthetic Rubber

MECHANICAL LEATHER PRODUCTS **sirvis**

CHICAGO RAWHIDE MANUFACTURING COMPANY

1304 Elston Ave., Chicago 22, Illinois

New York • Philadelphia • Detroit • San Francisco • Cleveland • Boston
Pittsburgh • Los Angeles • Cincinnati • Minneapolis • Syracuse • Peoria

Who said it costs more

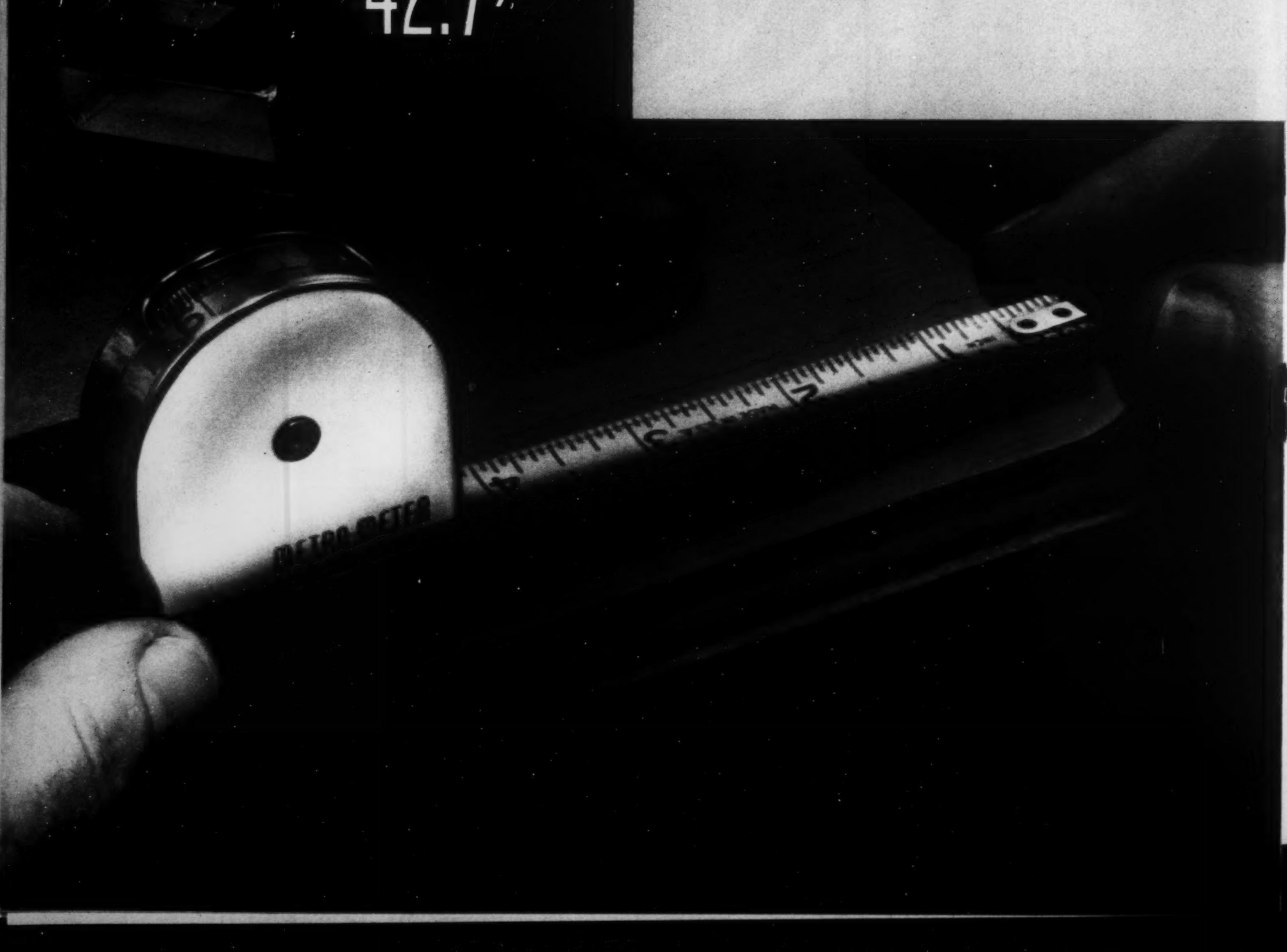
Here's where Stainless actually cuts cost 42.7%

COMPARISON AND

Cold Rolled Steel as against Stainless Steel

COLD ROLLED STEEL

Basic Cost of Tools Experienced life of tools plus average cost of maintaining dies, pro-rated basis.	$.0152
Punch Press Operations	$.0180
Preparation for Chrome Polish cold rolled before plating to remove "peel" and prepare finish to take clear color.	$.0224
Cost of Chrome Plating including depreciation of equipment.	$.1331
Plating Scrap Material scrapped because of prohibitive cost of stripping and re-chroming.	$.0140
Inspection	$.0060
Assembly line hold-ups Costs over Time Study standard hour due to "built-up" pieces and chrome flashes interfering with assembly.	$.0230
Finished units rejected or returned due to chipped or peeled plating resulting in "seconds" on line.	$.0480
Cost of material .025" Stock less scrap value.	$.0121
Total	$.2918



Wichita City Library

to use Stainless Steel?

ANALYSIS OF COSTS

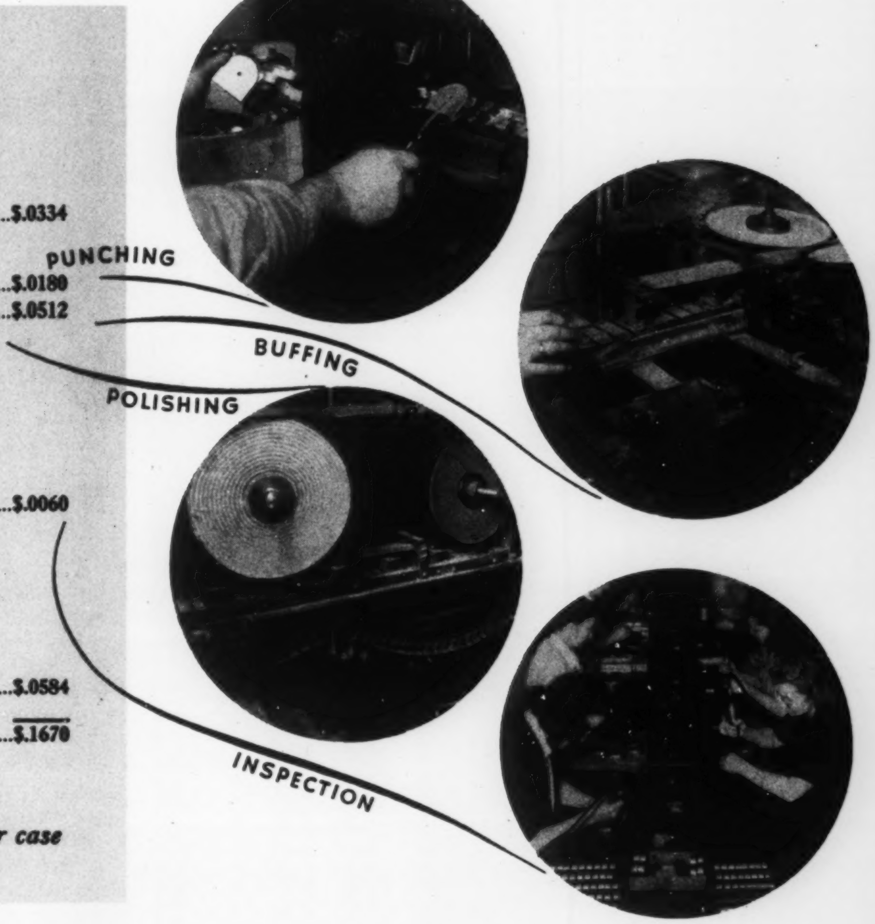
as experienced by Dart Mfg. Co., Mason, Mich.

STAINLESS STEEL

Basic Cost of Tools Experienced life of tools plus average cost of maintaining dies, pro-rated basis.	**$.0334**
Punch Press Operations	**$.0180**
Polish and Buff including depreciation of equipment and re-running of faulty buffing.	**$.0512**
Inspection	**$.0060**
Cost of Material .020" Stock less scrap value.	**$.0584**
Total	**$.1670**

Cold Rolled Total Costs	*$.2918*
Stainless Total Costs	*.1670*
Actual Experienced Savings	*$.1248 per case*

Percentage Reduction in Cost 42.7%



THE "Metro-Meter" is a little device you'll soon be seeing a lot more of. It's a dial-reading steel rule with built-in scribe that men just naturally "take to" because it's practical, obviously useful, and, encased in Stainless Steel, is permanently good looking.

It's the case we want to talk to you about. Originally it was made of cold rolled carbon steel, chrome plated. The steel, itself, was inexpensive. But by the time it was prepared for plating, and plated—after the costs for rejections and returns due to over-plating, under-plating, chipping and peeling were added—each case cost a little over 29 cents.

By using lustrous satin-finish Stainless Steel in place of cold rolled carbon steel, however, all plating costs as well as rejections and returns were eliminated. Even though the initial cost of the Stainless Steel used was about five times that of the carbon steel formerly used, the final *finished* cost in Stainless was exactly 16.7 cents per case—a saving of almost 12½ cents each, which means a 42.7% reduction in cost.

What is more, with the magic word "Stainless" now stamped on the case, an almost irresistible plus has been added. Sales for the "Metro-Meter" which formerly had been good, immediately became considerably better. Thus, Stainless has done here what it has done for many other products — improved appearance, increased durability and reduced sales resistance. And in this instance, it has actually reduced costs as well. In short, a product made of Stainless Steel does *not* necessarily cost more—it only looks as though it did.

• • •

We would be glad to have the opportunity to show you where U·S·S Stainless Steel can be applied to improve YOUR product — to increase its desirability — and, more often than you may expect, to reduce its cost as well.

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO
CARNEGIE-ILLINOIS STEEL CORPORATION, PITTSBURGH & CHICAGO
COLUMBIA STEEL COMPANY, SAN FRANCISCO · NATIONAL TUBE COMPANY, PITTSBURGH
TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM
UNITED STATES STEEL SUPPLY COMPANY, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

United States Steel Corporation Subsidiaries
Room 2061 Carnegie Building, Pittsburgh 30, Pa.

☐ **Please send me the new book, "An Introduction to U·S·S Stainless Steel."**

☐ **Please have a Stainless representative call on me.**

Name.......................................

Position.......................................

Company.......................................

Address.......................................

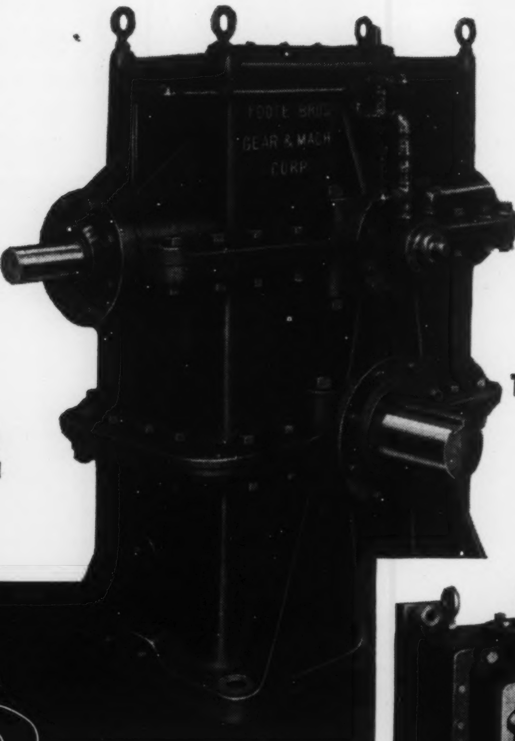
City...................... Zone.... State...........

USS

U·S·S STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS
PIPE · TUBES · WIRE · SPECIAL SECTIONS

UNITED STATES STEEL



1.

need a

drive like these?

2.

One of the services Foote Bros. renders industry is the production of drives such as these shown here to meet individual needs.

1. Here is a giant gear reduction unit engineered to stand the pounding, crushing force necessary in the production of asphalt tile.
2. Here is a textile mill drive that not only provides a number of shaft speeds, but also permits gear ratios to be changed quickly.
3. Here is a small, compact unit that permits a quick change from forward to reverse on a predetermined time cycle.

3.

If you are now using special drives on the equipment you manufacture, be sure to investigate the facilities of Foote Bros.' large plants completely equipped to produce gears and drives to meet practically any need.

If you are faced with a problem in the design of gears or transmission equipment, Foote Bros. engineers will gladly assist you in finding the correct solution.

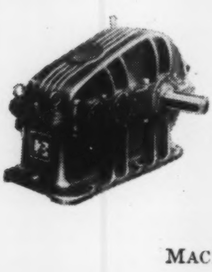
Of course, Foote Bros. also can furnish a complete range of standardized speed reducers to meet almost any industrial need. The more popular sizes and ratios are available from stock.

FOOTE BROS. GEAR AND MACHINE CORPORATION
Dept. O, 4545 South Western Boulevard • Chicago 9, Illinois

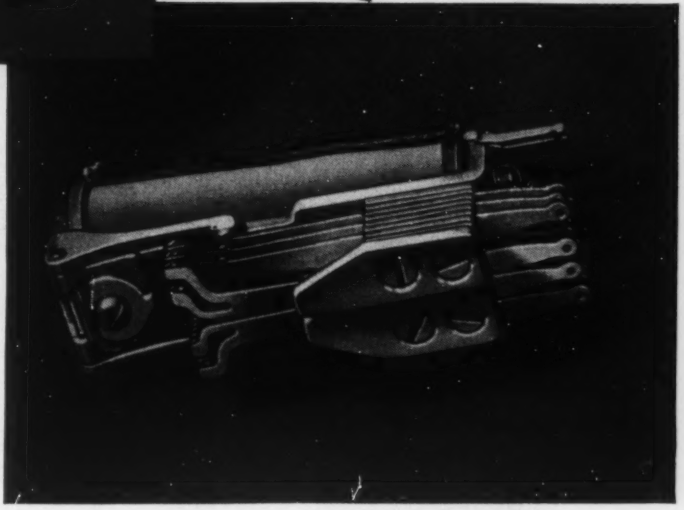
FOOTE BROS.

Better Power Transmission Through Better Gears

ENCLOSED GEAR DRIVES FOR ANY INDUSTRIAL USE



NOW all these features in ONE GREAT RELAY!



Independent twin contacts for perfect contact operation.

A highly efficient magnet circuit for sensitivity and high contact pressure.

Coil operating range: up to 300 volts, D.C., and 230 volts, A.C.

Any controlled circuit arrangement requiring up to 26 terminals.

Compact design for important savings in space and weight.

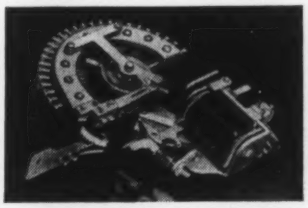
Unique armature bearing for long wear under severe conditions.

It's the Class "B" Relay

by AUTOMATIC ELECTRIC

Here's a relay that steps out from the crowd—a relay even better than Automatic's widely used, *widely copied*, Class "A" relay. Use the Class "B" for your most exacting application—and discover for yourself its wide margin of superiority in sensitivity . . . dependability . . . compactness . . . versatility . . . and long wearing qualities!

The Class "B" Relay and many others are described in catalog 4071—write for your copy.



TYPE 45 ROTARY SWITCH

A rotary switch that's new and better! 70 steps a second speed . . . up to 10 (or more) bank levels . . . only one field adjustment. Ask for literature.

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Speer carbon brushes REFLECT years of research

Typical of Speer Carbon Company's electrical laboratory equipment is this Speer-Developed Automotive Brush Testing Apparatus.

Reflected in every Speer carbon brush are the results of 50 years of research – advancements that have kept pace with industry's demands for better commutation, through modern, fully equipped and completely staffed laboratories – part of Speer Carbon Company's highly developed organization.

These complete facilities are available at any time to devote attention to your present or future requirements.

SPEER

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CARBON COMPANY
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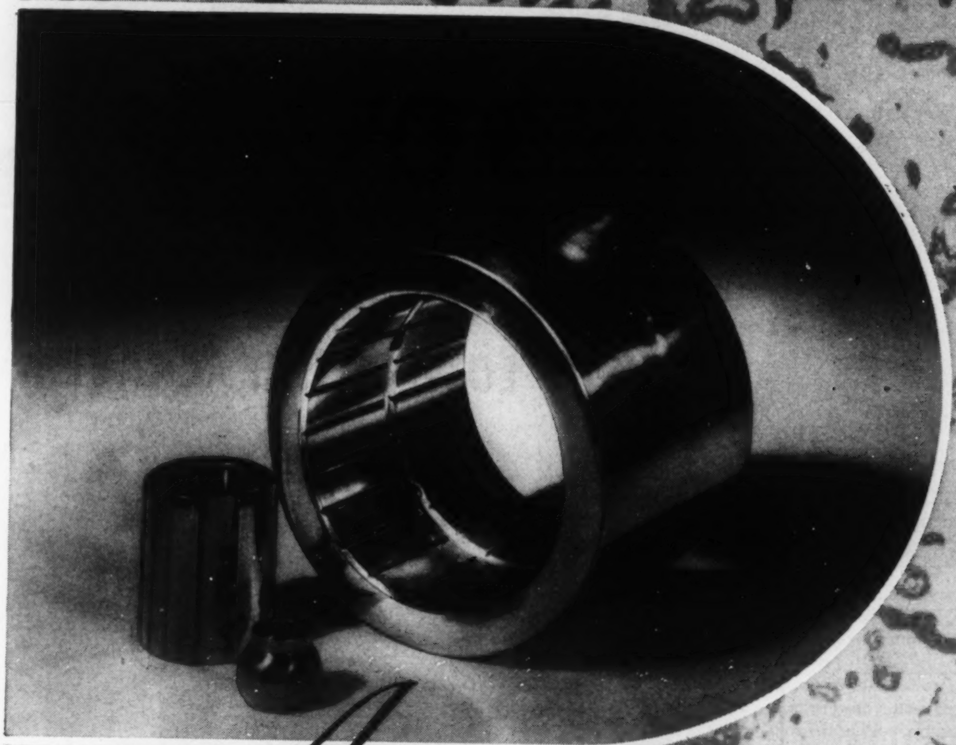


ABILITY to carry heavy loads in limited space is an attribute of the sleeve bearing. Typical of Bunting Bearings used for such applications are the crankshaft main, connecting rod and piston pin bearings of internal combustion engines. On your bearing problems, consult Bunting engineers. The Bunting Brass & Bronze Company, Toledo 9, Ohio., Branches in Principal Cities.

Bunting

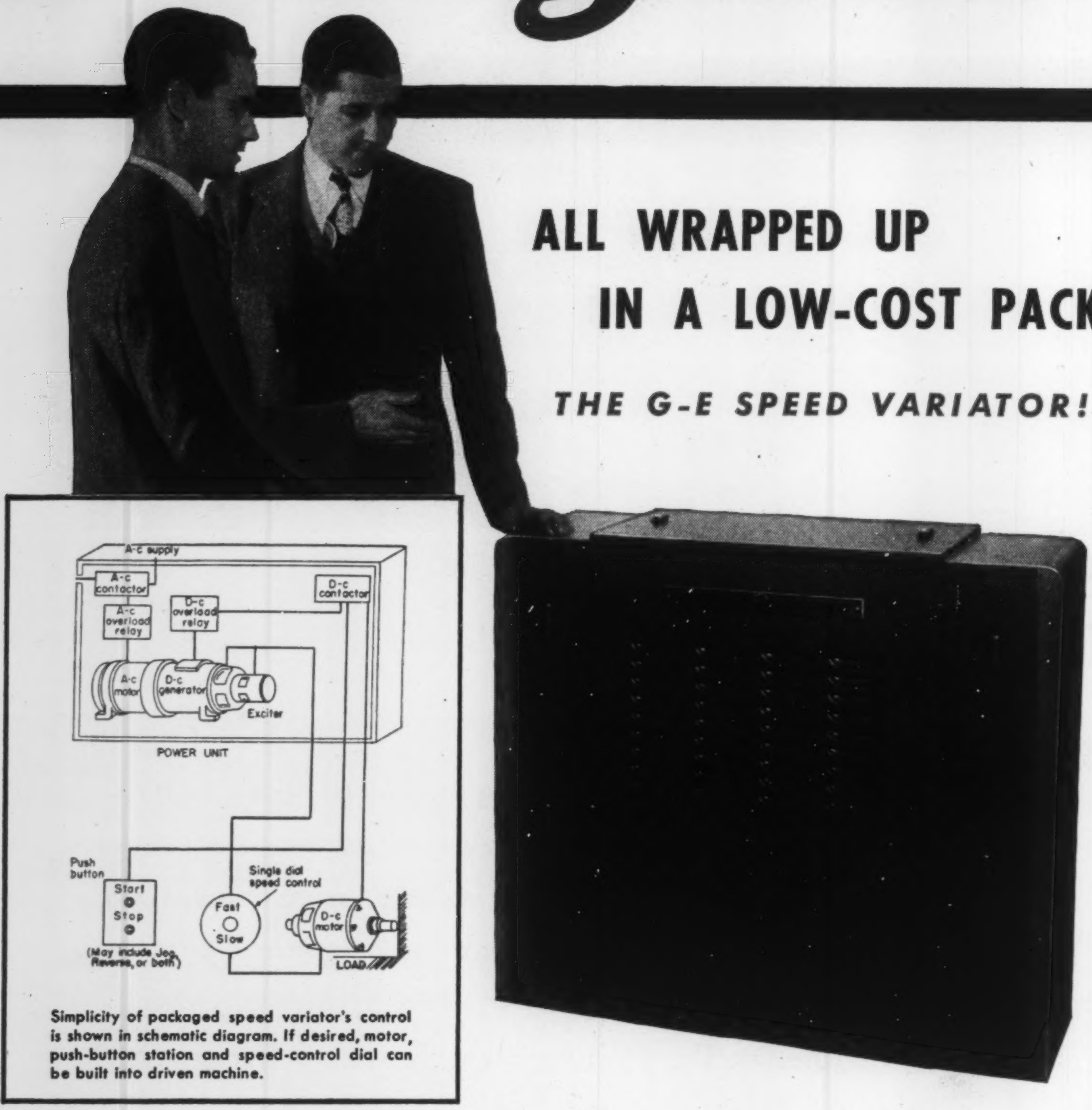
BRONZE BEARINGS ☆ BUSHINGS ☆ PRECISION BRONZE BARS

52

Designer's

ALL WRAPPED UP IN A LOW-COST PACKAGE

THE G-E SPEED VARIATOR!


A-c supply
A-c contactor
A-c overload relay
D-c overload relay
D-c contactor
A-c motor
D-c generator
Exciter
POWER UNIT
Push button
Start
Stop
(May include Jog, Reverse, or both)
Single dial speed control
Fast
Slow
D-c motor
LOAD

Simplicity of packaged speed variator's control is shown in schematic diagram. If desired, motor, push-button station and speed-control dial can be built into driven machine.

Now you can incorporate in your designs—at low cost—an adjustable-speed drive that gives the desirable performance of a d-c motor from an a-c power supply. With the G-E packaged Speed Variator, you can obtain smooth, flexible speed control over a 16 to 1 speed range. And because of mass production from standardized parts, you get an engineered system at an economical price, built for your particular application.

Longer life and lower maintenance costs are obtained from the new, compact, air-filtered power-unit case which encloses motor-generator set and control. Factory assembly and unit shipment reduce installation cost. Drive ratings of 3 through 60 hp are available. Ask for Bulletin GEC-280.

GENERAL ELECTRIC

Digest

TIMELY HIGHLIGHTS ON PRODUCTS

FOR MACHINES WITH THE "SHAKES"

From the design standpoint, excessive vibration in moving machinery means trouble. With the G-E recording vibrometer, you can quickly find out the source and degree of vibration and provide for corrective balancing. This lengthens equipment life, saves design and maintenance costs. The vibrometer makes a permanent record of frequency, displacement, and waveshape in mechanical vibration. It records both steady-state and transient vibrations. Operation is simplicity itself. Just hold the prod extending from the vibrometer against the vibrating body, as illustrated. See Bulletin GEC-310.

TIME SWITCHES THAT "SAY WHEN"

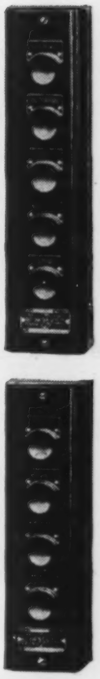
Here's the lowest-priced high-quality G-E time switch ever—the T-47. A "natural" for low-cost control of motors, heaters, lights, fans, blowers, and similar equipment, it automatically performs one "on" and one "off" operation during any 24-hour period, and repeats daily without further adjustment. It saves electricity, reduces losses due to negligence, and releases operators for other work. Available from stock. See Bulletin GEA-4874.

NEW! HANDY CONTROL BOOKLET

SIMPLIFIED GUIDE
A-C MOTOR CONTROL

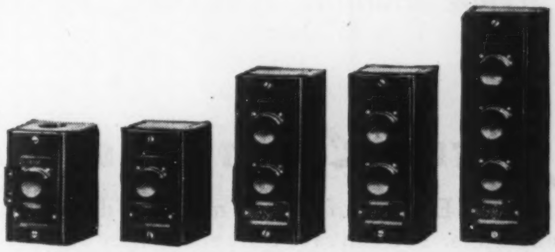
You'll get a quick, helpful review of an important subject for machine designers in "Simplified Guide to A-C Motor Control." Here you'll find pointers on the various functions of control, how to select and apply the commonly used types, when and how to use magnetic and manual control, overload and undervoltage protection, enclosures, etc. See Bulletin GEA-4015.

Off to a Good Start



Add the right touch to your machine designs with one of G.E.'s heavy-duty push-button stations. Designed for use with magnetic controllers, they're made for flush or surface mounting in general-purpose, dust-tight and watertight cases, and in enclosures for use in hazardous areas. Interchangeable units permit many combinations at one station of momentary and maintained contact buttons, selector switches, and indicating lights.

Sturdy, steel enclosures and ample electrical clearances assure operator safety. Large double-break contacts stand up under frequent operation. Installation of the surface-mounted stations shown is simple. Remove the cover and bolt to the desired surface through the mounting holes provided. Easily accessible terminals then make wiring a matter of seconds. See Bulletin GEA-5043.



General Electric Company, Section G668-66
Apparatus Department, Schenectady 5, N. Y.

Please send me the following bulletins:

- ☐ GEC-280—Packaged speed variator
- ☐ GEC-310—Recording vibrometer
- ☐ GEA-4874—T-47 time switch
- ☐ GEA-4015—A-c motor control guide
- ☐ GEA-5043—Push-button stations

YOUR McGRAW-HILL ELECTRICAL CATALOGS show "everything electric" for machinery manufacturers in the G-E section.

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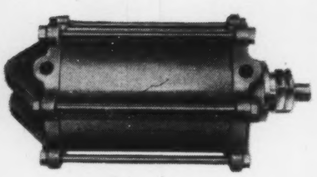
Company ....

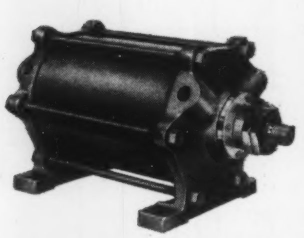
Street ....

City...State.....................

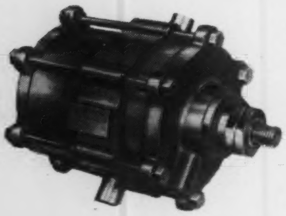
To Meet Your Needs



CLEVIS MOUNTING
1" to 12" Bore

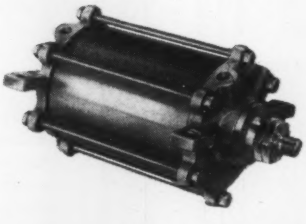


FOOT MOUNTING
1" to 12" Bore

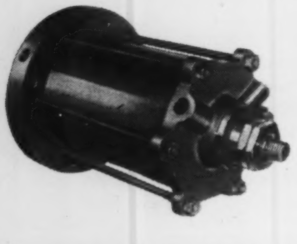


TRUNNION MOUNTING
1" to 12" Bore

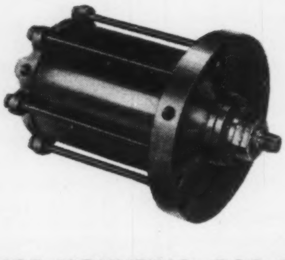
HONED
Tru-Bored



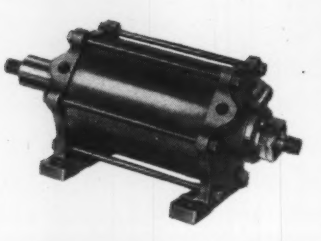
CENTERLINE MOUNTING
3" to 12" Bore



FLANGE MOUNTING, HEAD END
1" to 12" Bore



FLANGE MOUNTING, ROD END
1" to 12" Bore



DOUBLE END PISTON ROD, FOOT MOUNTING*
1" to 12" Bore
* Other styles also available.

THE *Line* THAT'S COMPLETE!

HERE'S help for busy machine designers and plant operating engineers. You can save time and money right from the start by checking with Hannifin on all of your pneumatic cylinder requirements. *The Hannifin line is complete!* For quicker delivery and maximum economy, virtually any need can be met with a standard Hannifin precision-built cylinder: 10 standard bore diameters, 1" to 12"... 6 basic mounting styles; plus double end rod and combination styles . . . any length stroke, double acting or single acting . . . with or without adjustable cushions for head cap, rod cap, or both.

Let Hannifin engineers help you get the *BEST* solution for your cylinder problems. Recommendations backed by more than forty years of specialized engineering experience. Latest catalog on request.

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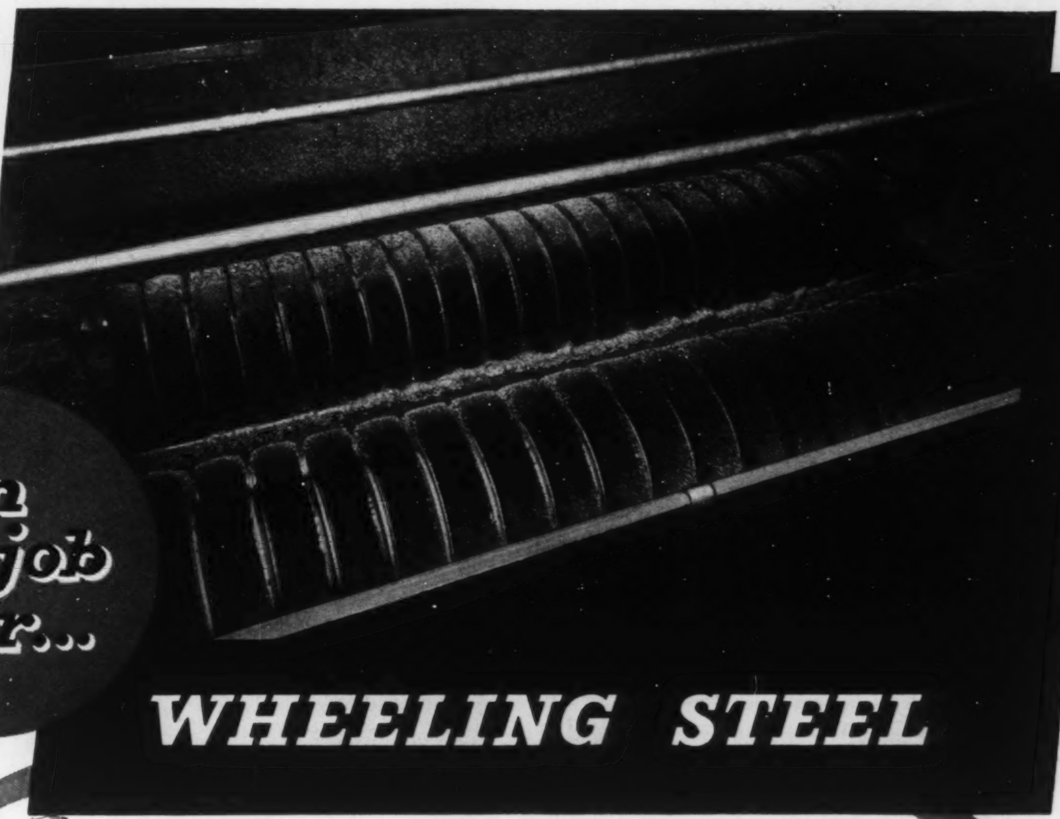
"PITTSBURGH" *Power Driven* BRUSHES

A "Pittsburgh" power-driven brush in operation at the Steelcrete Division of Wheeling Steel, Beach Bottom, W. Va. This special brush is on the job every day deburring and cleaning large sheets of Expanded Metal.



On the job for...

WHEELING STEEL

Pittsburgh's ingenuity in designing special brushes for unusual jobs is sought time and time again by leading firms in almost every industry. Wheeling Steel, for example, recently put its brushing problem before Pittsburgh's staff of skilled brush engineers.

Selecting a .014 steel wire with pre-tested fast cutting qualities, Pittsburgh engineers designed and built a *Perfect Balance* rotary brush that could take a beating and come right back for more. The brush was *stiff* enough to remove stubborn burrs. It was *tough* enough to penetrate and thoroughly clean the metal. And it was *soft* enough not to impair surface texture.

The brush did the job right from the first day it was put into operation—another example of Pittsburgh's ability to cope with the most difficult brush problems.

There's a "Pittsburgh" Brush for Every Industrial Use!

- GLASS
- STEEL
- PLASTICS
- AUTOMOBILE
- RUBBER
- PAPER
- TIRE and RETREADING
- SHOE MANUFACTURING and REPAIRING

In the complete Pittsburgh line are brushes of all types, including "Perfect Balance" sections, wheels and assemblies. Consult the Pittsburgh engineering representative. He will gladly work with you in developing any type of power-driven brushes to meet your particular finishing specifications.

Phone or write Pittsburgh Plate Glass Company, Brush Division,
3221 Frederick Ave., Baltimore—29, Maryland

Power Driven BRUSHES

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PITTSBURGH PLATE GLASS COMPANY

Frictionless as Flight!

Only Federal Noark Motor Starters have free action . . .
the one moving unit floats on ball bearings

YOU DON'T SEE the ball bearings, but push up that moving unit and you *know* they're there. Only a featherlight touch is needed! And only Federal Noark Motor Starters give you that floating ball bearing action—with consequent longer and trouble-free service life.

But chalk up too, these additional advantages of Federal Starters! Their overload relays allow you the choice of automatic or manual reset by merely turning a knob. Coils are replaced in a matter of seconds. All parts are readily accessible from the front.

Order Federal Noark Motor Starters from your Federal Distributor and save time, effort and money. And write us for free copies of the "Federalog" and "Simplified Motor Control" giving full descriptions. Federal Electric Products Company, 50 Paris St., Newark 5, N. J.

FEDERAL NOARK
MOTOR STARTERS

Complete line of Federal Electric Products includes Motor Controls, Safety Switches, Service Equipment, Circuit Breakers, Panelboards, Switchboards, Control Centers, Bus Duct ★ Sales offices in principal cities.

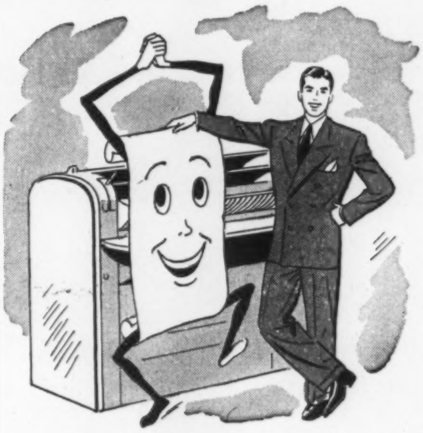
Month after Month–
OZALID materials are UNIFORM!

SHIPMENT AFTER SHIPMENT, month after month, Ozalid materials are in balance!

They are constant in printing speed, in reprint speed, in image color and image density, and in dozens of other characteristics *which give peak efficiency to an Ozalid operation.*

This uniformity means that the Ozalid operator's time is spent in feeding material into the machine, rather than testing, retesting... then starting all over!... to learn the differing characteristics of each new package of sensitized material.

In addition, Ozalid materials show scrupulously maintained *superiority*. Scientific tests on every batch of Ozalid materials assure an ideal balance of physical strength, higher resistance to fading, covering power, and *keeping qualities* unmatched by any other diazo-sensitized materials.



Ozalid's continuous laboratory control comes free with every package of Ozalid materials! And–Ozalid's nationwide technical organization is ready to help you in any part of the country.

NOTE TO NON-USERS OF OZALID:

Do you know the story of America's Simplest Business System? Ozalid duplicates anything drawn, typed, or written in as little as 25 seconds! Ask for FREE booklet outlining the many ways in which Ozalid can save you time and dollars. Consult your classified directory or write to...

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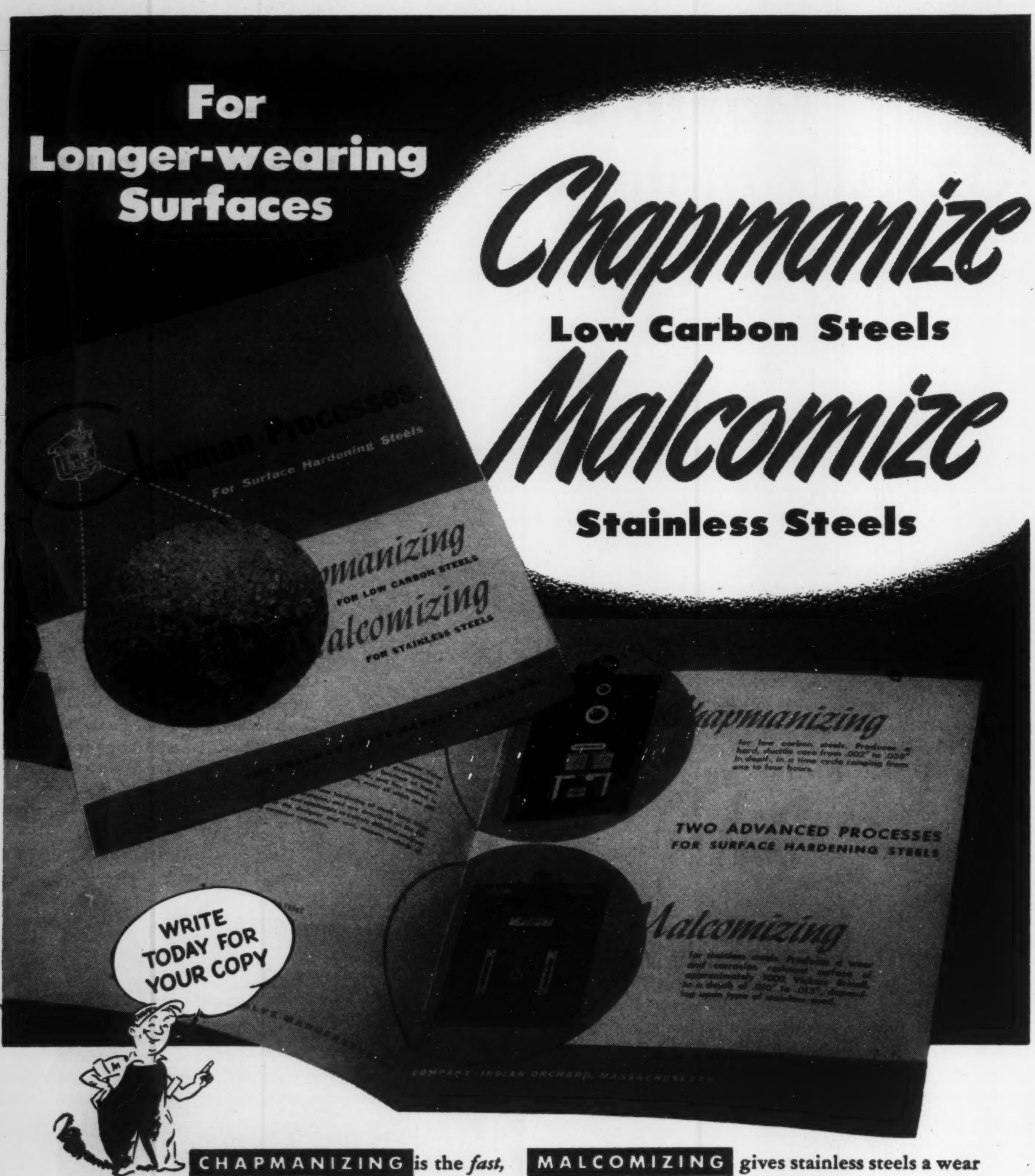
A Division of General Aniline & Film Corp.
"From Research to Reality"

DON'T COPY!... USE **OZALID!**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TWO ADVANCED PROCESSES FOR SURFACE HARDENING STEELS
Malcomizing
COMPANY INDIAN ORCHARD, MASSACHUSETTS
WRITE TODAY FOR YOUR COPY

CHAPMANIZING is the *fast, modern way* to surface harden free-working steel. In only 1 to 4 hours it will give you an alloy-like case from .002" to .035" deep — a case so tough and ductile it will not chip or check. Because the surface comes out silver-clean, minimum finish grinding is required.

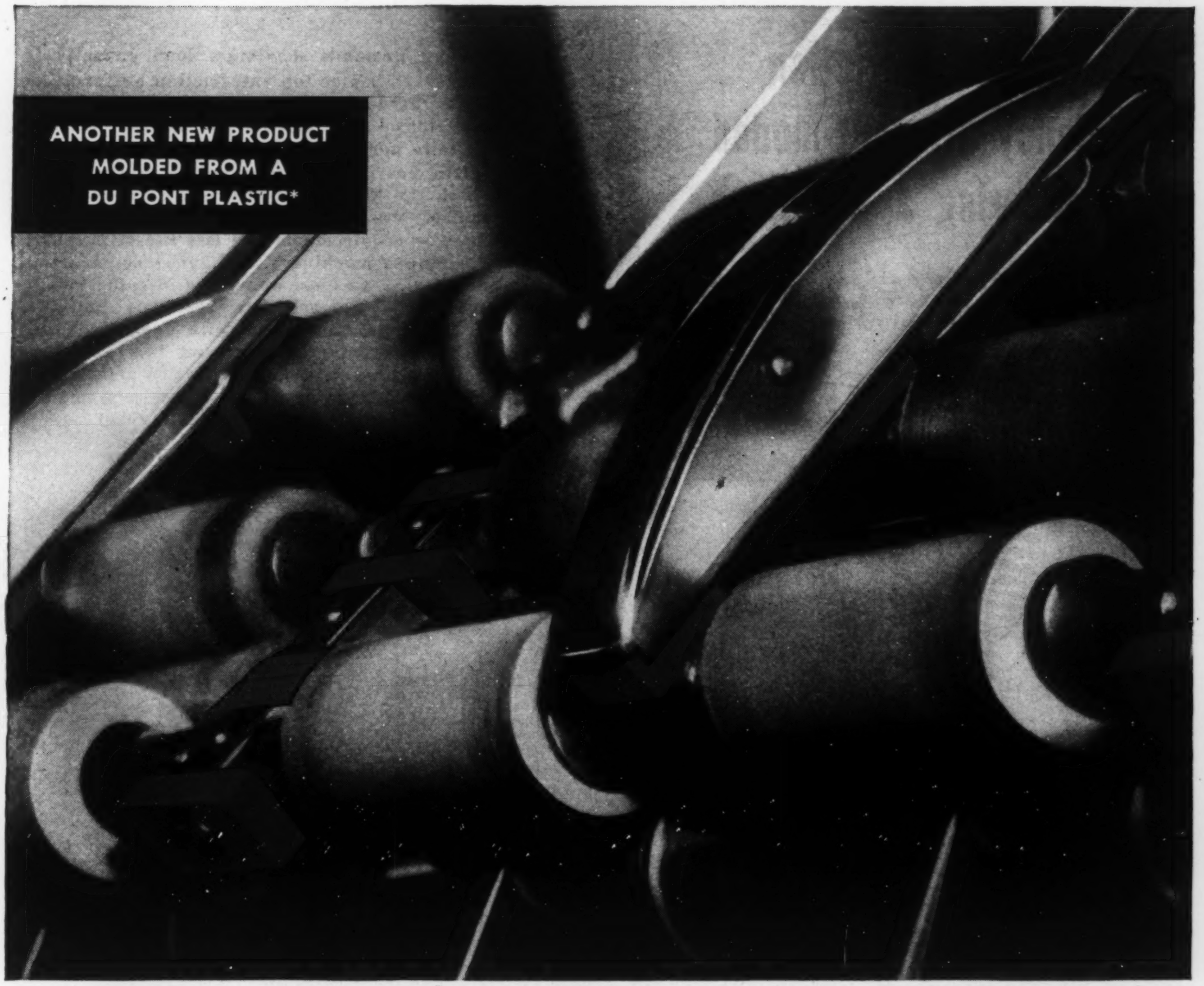
MALCOMIZING gives stainless steels a wear and corrosion resistant surface with an average hardness of 1000 Vickers. Depth of case ranges from .005" to .015" depending on the type of steel. After Malcomizing you can finish grind or lap . . . maximum hardness is slightly below the surface.

We'll be glad to send you a copy of the bulletin describing these two Chapman processes for low carbon and stainless steels. Just write for "Chapman Processes."

Metallurgical Sales Division of

The Chapman Valve Mfg. Co.

INDIAN ORCHARD, MASSACHUSETTS



ANOTHER NEW PRODUCT
MOLDED FROM A
DU PONT PLASTIC*

NEW NYLON BEARINGS NEED NO LUBRICATION

Textile-machine parts of Du Pont nylon plastic last for years . . . slash costs

Oil has long been a problem in the making of yarn. In spinning, the yarn is drawn through rollers that stretch and align the fibers. The parts that keep these rollers weighted and in place are called "saddles" and "cap bars." The bearing surfaces of the saddles and cap bars require frequent time-consuming oilings. An average mill may have as many as *135,000 such places to oil* as often as once a day. Frequently, oil gets on the rollers and is transferred to the yarn—necessitating costly cleaning. In addition, the oily rollers pick up lint that must be removed by hand. And when the oil supply on the bearings gets low, the rollers slow down and cause uneven spinning.

But today, yarn makers can solve this problem. For when molded *nylon* bearings replace metal bearings, no lubrication is necessary. They can be installed and practically forgotten. In one textile plant, nylon bearings have been in constant use, without oiling, on all three shifts *for two years . . . and still show little or no wear*.

Big savings result here because use of nylon bearings 1) eliminates oiling, 2) reduces yarn damage, 3) helps maintain uniform yarn quality, 4) virtually ends roll-picking, 5) reduces average power consumption.

This success story is typical of those you'll hear about products molded of nylon. Can nylon plastic solve a problem for you? Write today for helpful facts about this and other versatile Du Pont plastics. Just address E. I. du Pont de Nemours & Co. (Inc.), Plastics Dept., Room 393, Arlington, N. J.

**Saddles and cap bars manufactured by Dixon Lubricating Saddle Co., Bristol, R. I., under the trademark "Slixonice," are equipped with nylon bearings molded by Atlantic Plastics, Inc., Flushing, L. I., N.Y.*

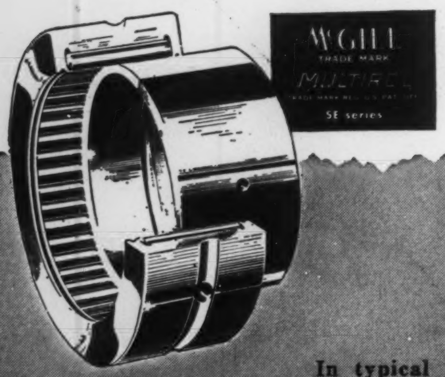
Tune in—Du Pont's famous "Cavalcade of America"—Monday night, NBC coast to coast!

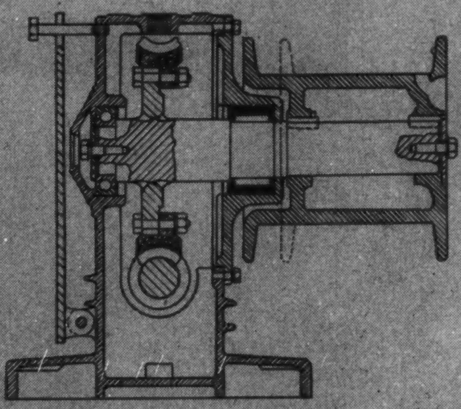
DU PONT
REG. U. S. PAT. OFF.
Plastics
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

design anti-friction efficiency into out-moded plain bearing applications

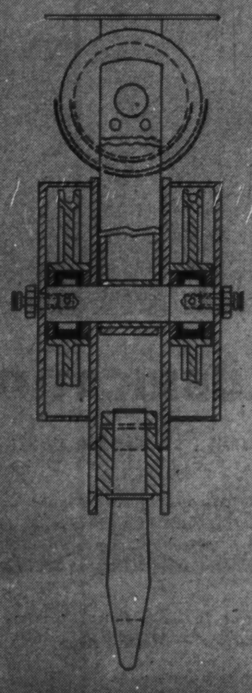
THE MULTIROL WAY

When design demands maximum load capacity in limited space . . . plus top anti-friction performance . . . get results with MULTIROL SE Series full type roller bearings. MULTIROL SE Series bearings afford definite performance advantages over friction bound plain bearings. They increase machine efficiency with the kind of smooth precision operation that requires less maintenance for longer machine life — power requirements are less for MULTIROL bearing equipped machinery. SE Series construction is simplified . . . no loose or welded in roller retaining washers . . . lubrication reservoir built in. Smaller radial bearing space with increased load capacity permits more compact and less expensive housing facilities. All add up to improved anti-friction performance. Use with or without inner race in shaft sizes from ⅜" to 9¼". Write for data now!

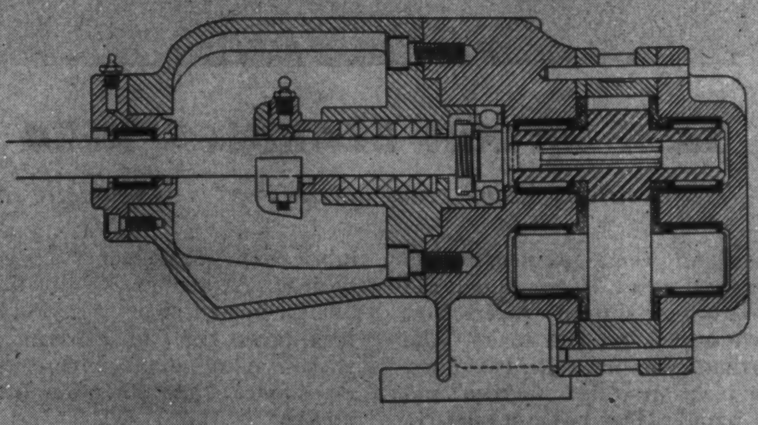




In typical capstan application MULTIROL SE Series maximum capacity bearings fit the small space under the cable drum, yet accept large diameter shaft necessary to carry heavy overhung load.



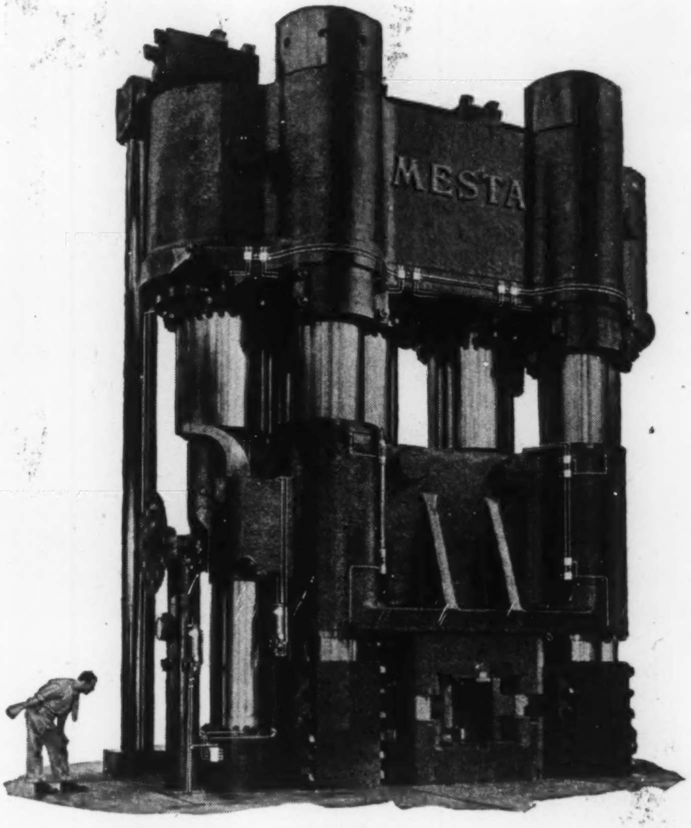
Use MULTIROL SE Series bearings on sheaves for maximum shaft diameter of pin and minimum housing OD . . . increases load capacity. Lubrication with Alemite fittings need less care than oil bath with plain bearings.



On a rotary gear pump, the heavier load capacity and comparatively small OD of SE Series MULTIROL Bearings permits use of larger shaft that resists deflection. Precision anti-friction requires less power imput.

Interested in SE Series MULTIROL bearing advantages? Write today for your copy of Bulletin SE-48. McGill Manufacturing Co., Inc. 200 N. Campbell St., Valparaiso, Indiana

McGILL
TRADE MARK
precision bearings



FARVAL—*Studies in Centralized Lubrication*
No. 107

World's largest forging press is lubricated with 2 Farval systems

THE builder of this 18,000-ton hydraulic die forging press made certain it would receive adequate lubrication by equipping it with two Farval systems. One serves 24 points of lubrication on the column guide bushings and plunger seat, the other serves 32 points on the gland rings of main and push back cylinders.

Hundreds of Farvalized presses are in use in forging and metal working shops. The benefits of Farval Centralized Lubrication are fourfold—oiling labor is saved, lubricant is saved, bearing expense saved and production time saved. In one plant, for example, installation of 133 Farval systems to serve 3100 bearings on metal-forming presses saved the labor of 11 oilers per day.

In another plant, Farval solved the problem of delivering oil regularly and adequately to the Pitman bearings of a large forging press, thereby ending frequent shutdowns for overhauls costing $3500 to $5000 each in parts and labor alone. In a third plant, five Farval-equipped dieing machines ran continuously for 10,000 hours, while alongside, 12 similar machines without Farval had to be shut down every four hours for hand oiling. Thus production was increased 14% on the Farval-equipped machines and maintenance was only ¼ as great.

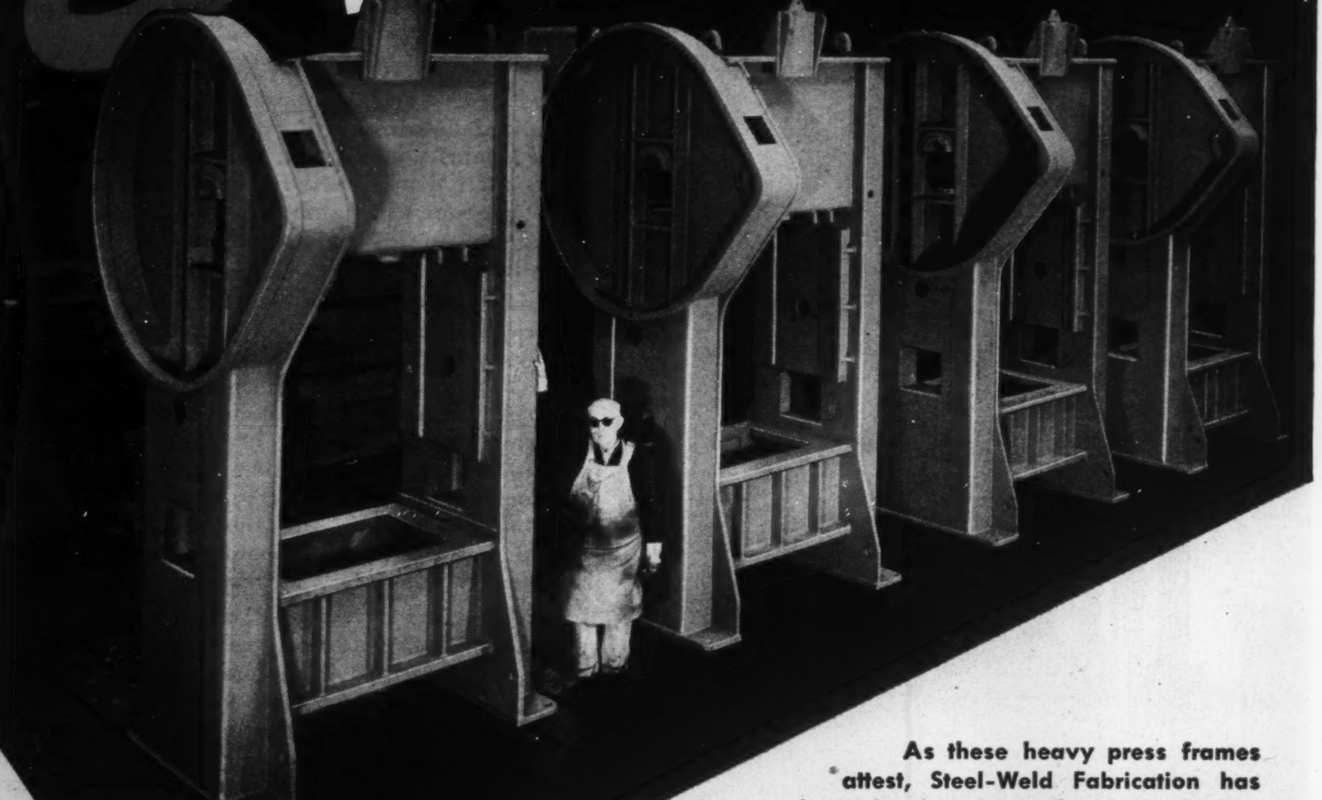
Farval systems have served industry for over 20 years. Farval delivers oil or grease under pressure to a group of bearings from one central station, in exact quantities, as often as desired. It does its work while the machine is in operation. Farval—the Dualine System with the Positive Piston Displacement Valve—that has but 2 Moving Parts—is Fully Adjustable—and with a Tell-tale indicator at each bearing to show the job is done.

Write for Bulletin 25 for a full description of Farval. The Farval Corporation, 3265 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.

FARVAL
CENTRALIZED
SYSTEMS OF
LUBRICATION

Steel-Weld FABRICATION



As these heavy press frames attest, Steel-Weld Fabrication has been developed to a fine art by Mahon craftsmen . . . this is true of any type of welded steel base, frame, or heavy machinery part produced in the Mahon plant, regardless of size, shape or weight. The Mahon organization is also fully equipped to handle heavy machine work of all types up to unusual dimensions. These facilities and highly skilled craftsmen, backed by a staff of design engineering experts, assure you of a source which will produce for you a better, smoother appearing job, embodying every advantage of Steel-Weld Fabrication.

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Detroit 11, Michigan

Engineers and Fabricators of Welded Steel Machine Bases and Frames, and Many Other Welded Steel Products

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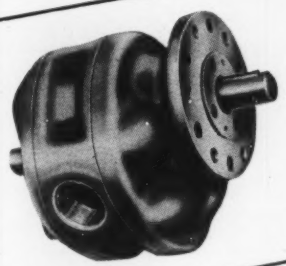
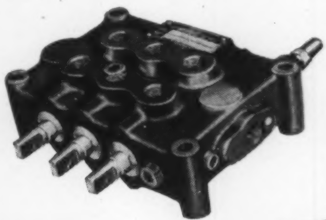
for **ALL THREE!**



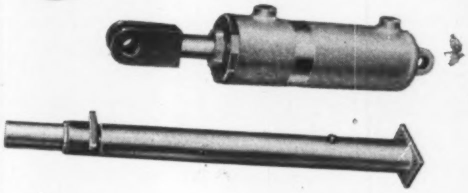
PUMPS

Five basic sizes, from 2¼ GPM to 130 GPM at pressure up to 1000 PSI. Available with flange or base mountings. Spur gear design with anti-friction roller bearings.



VALVES

For operating one or more single or double-acting cylinders — 5 GPM to 85 GPM capacities at pressures up to 1400 PSI. Patented Hollow-Plunger* design with built in check valve.



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TYPE SG-10x48A

Features-

- Double column support for grinding wheel head.
- Automatic, adjustable grinding wheel feed.
- Automatic wheel feed for trueing.
- Automatically cushioned trueing position.
- Automatic lubrication of ways.
- Axial grinding wheel spindle adjustment.
- Work table speeds up to 70 ft. per minute.
- Control panel, with counters to adjust grinding cycle, interlocking safety features, very accessible mountings of push buttons and other controls.
- Long base eliminates work table overhang. New way guards.
- Simplified stroke adjustment.
- Adjustable work arbor supports facilitate loading.
- Recessed dogs and stops, for operator's safety.

For grinding involute gears and splines this machine can be equipped with the Geargrind Involute Trimmer. This has the capacity to true wheel from 32 to 4 diametral pitch. Gear diameters from ¾" R.D. to 10" O.D.

CAPACITY—SG-10x48A

Between Centers	Up to 48"
Spline OD	1" to 6"
Max. swing	12½"
Teeth	4 to 120
Face width	Up to 34"

GEARGRIND
DETROIT USA

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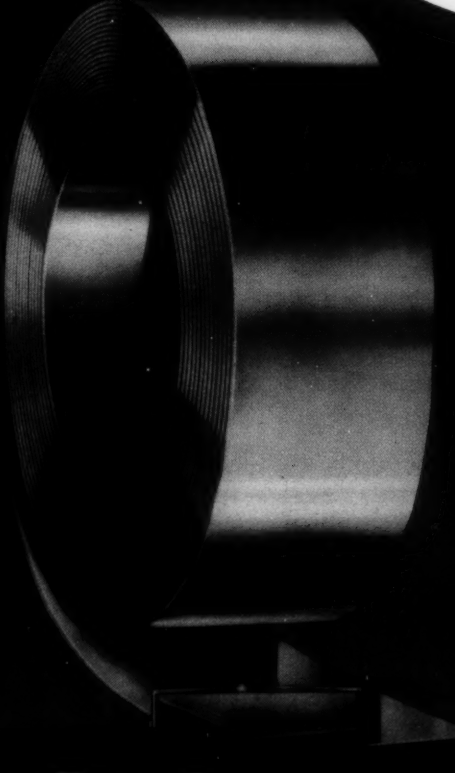
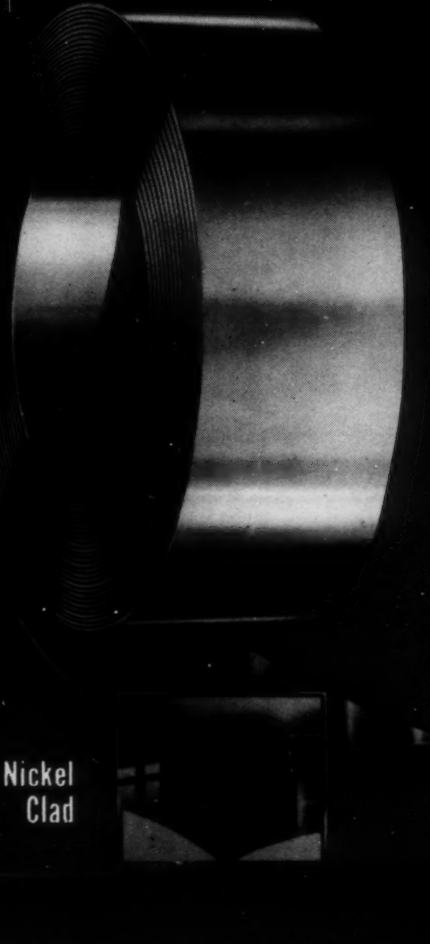


Monel Clad



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Superior Steel

CORPORATION

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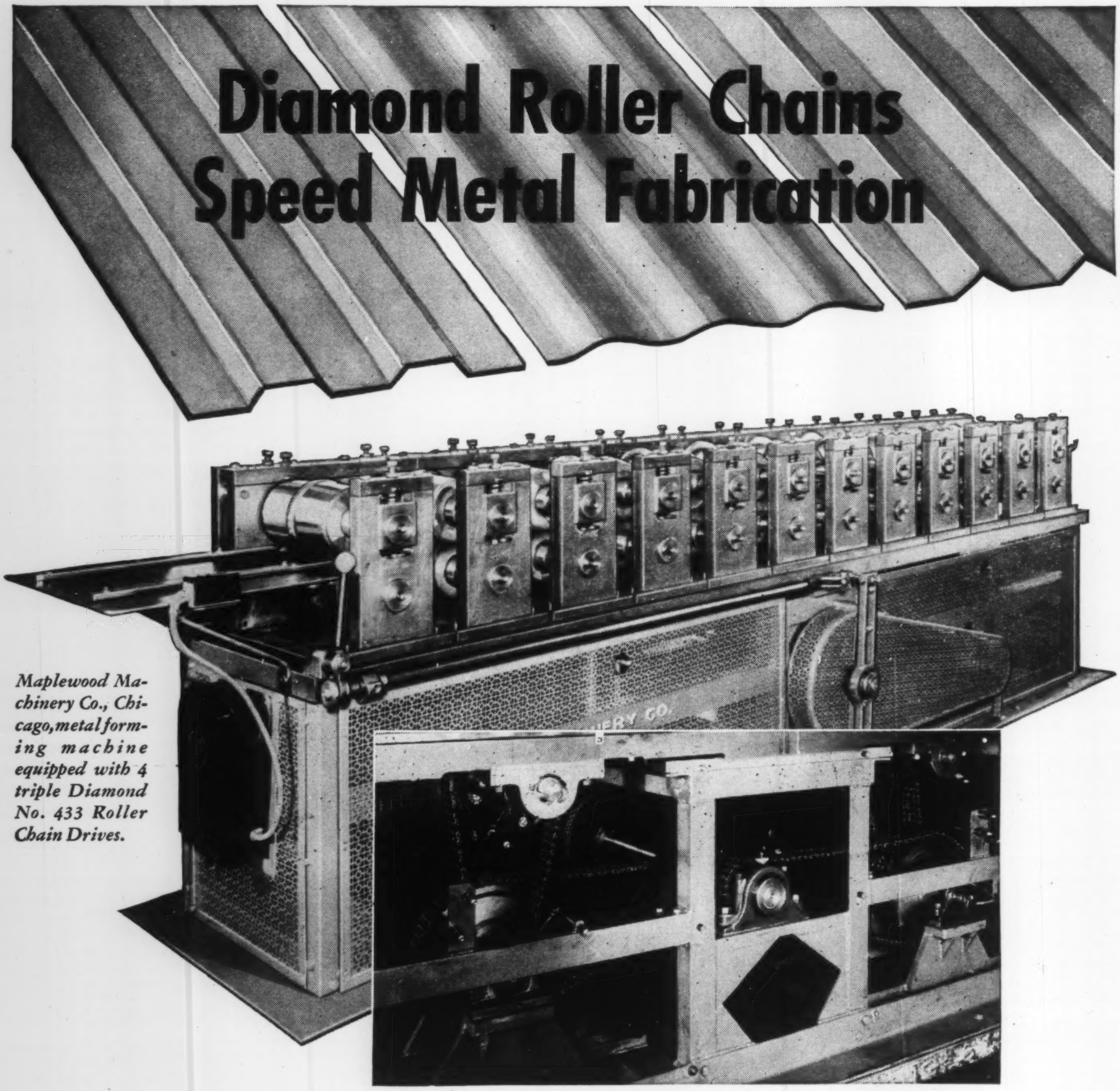
Diamond Roller Chains Speed Metal Fabrication



Maplewood Machinery Co., Chicago, metal forming machine equipped with 4 triple Diamond No. 433 Roller Chain Drives.

● Operating the forming rolls on the high speed Maplewood metal fabricating machines, Diamond Roller Chains provide the non-slipping positive drives required for maximum output.

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TYPE H1 in sizes up to 1/2 horsepower

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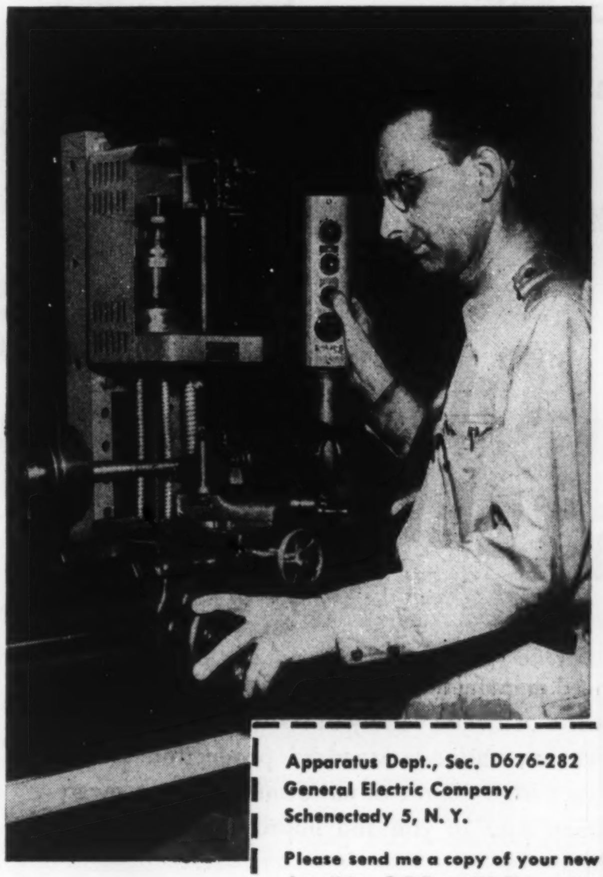

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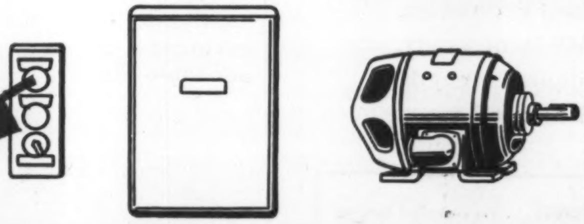

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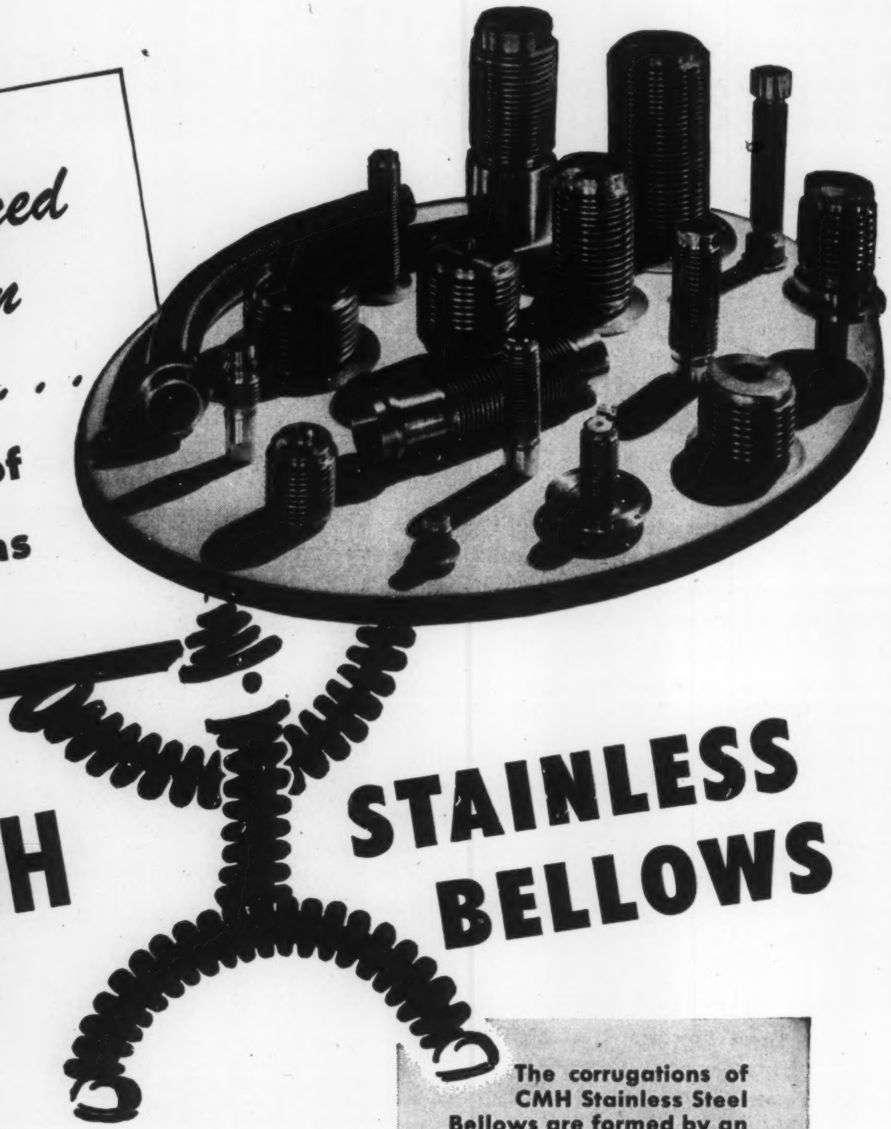

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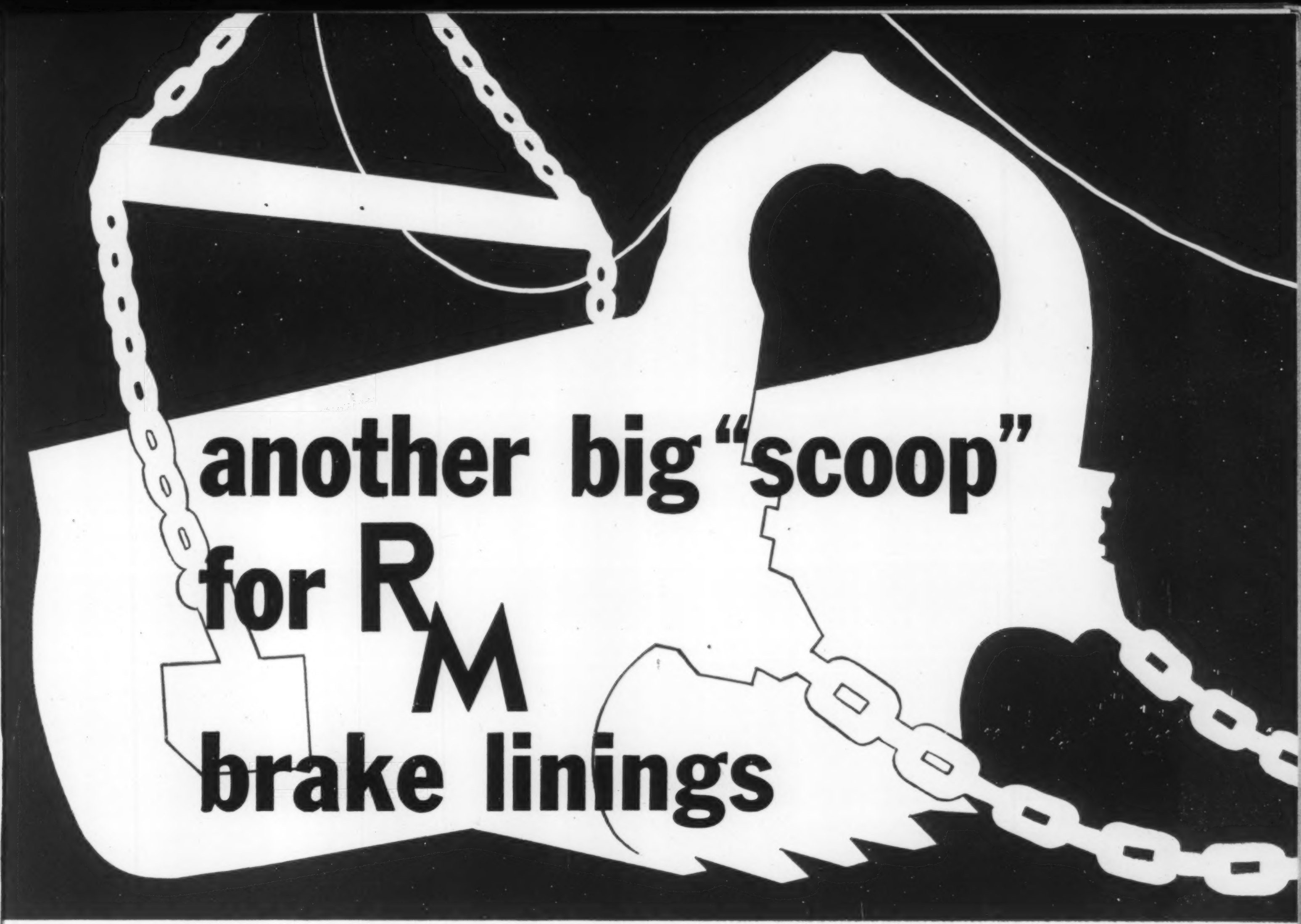
***In Canada:* Canadian Metal Hose Co., Brampton, Ont.**



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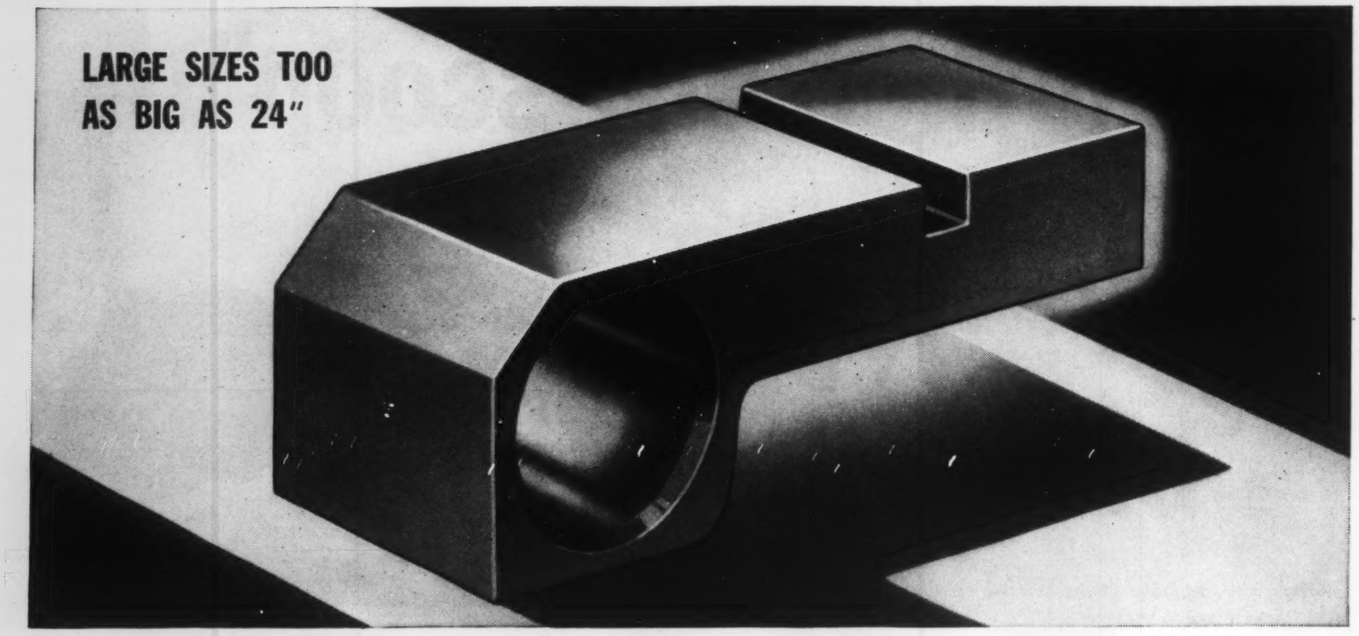

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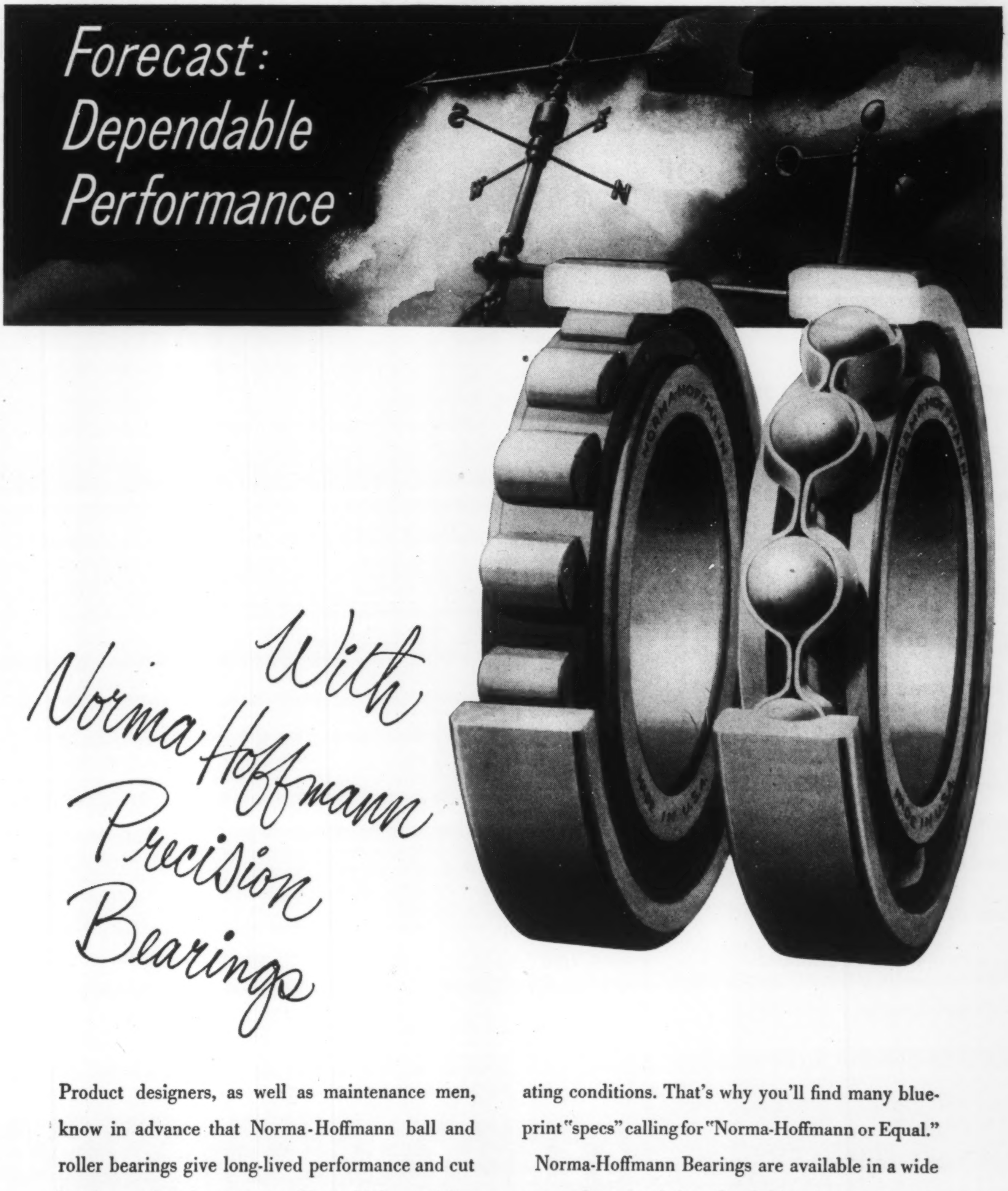

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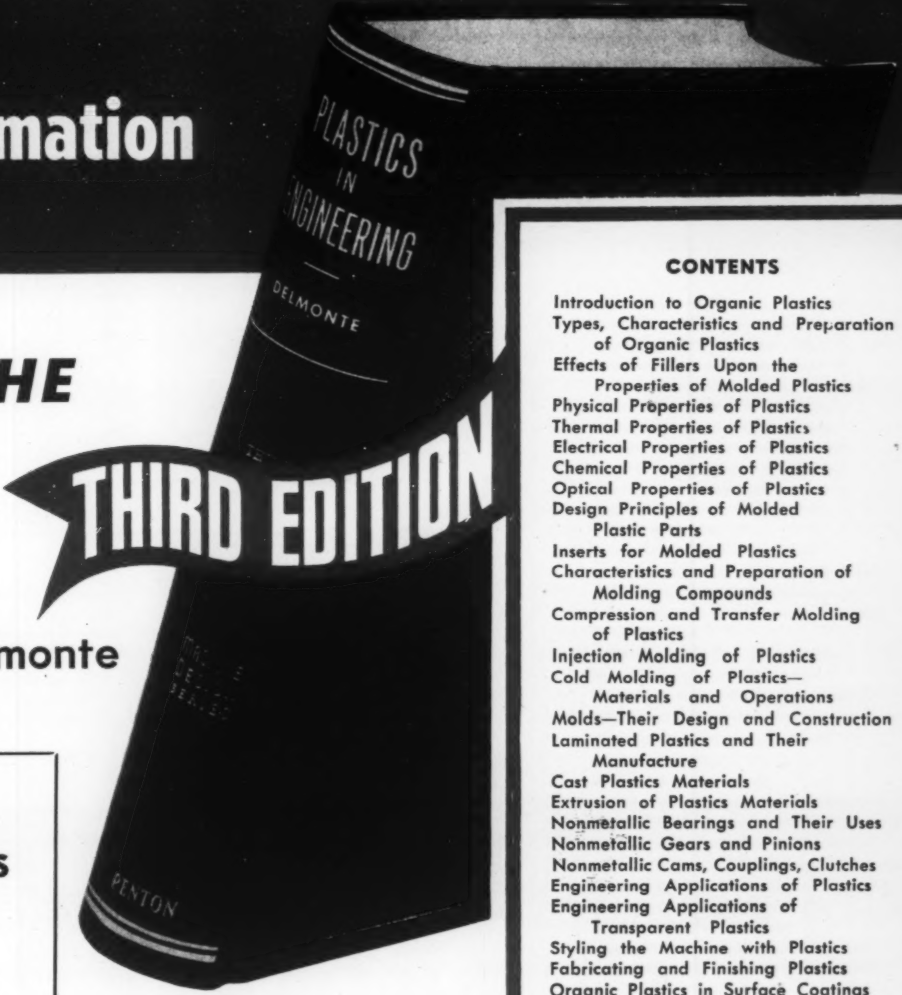

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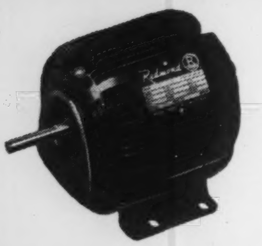

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4-POLE SHADED POLE
1550 R.P.M.

Heavy duty Fin-Line die cast case, open ventilated. Precision wound, humidity and oil resistant coils. Die cast rotor. Super capacity oil reservoirs. Circulating lubrication. Available with rubber mounted base, or 4 mounting studs.

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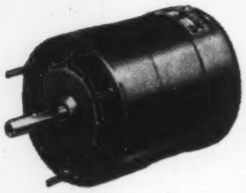
Rugged drawn steel case, open ventilated. Accurate count varnished coils. Precision cast rotor. Large oil reservoirs and individually fitted, self-aligning bearings. Available with resiliently mounted base or 4 mounting studs.



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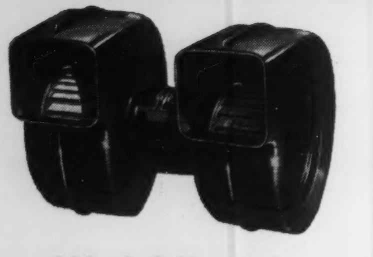
6-POLE SHADED POLE
1000 R.P.M.

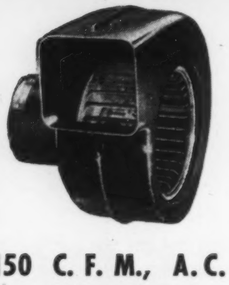
Sturdy drawn steel case, open ventilated. Positive count machine wound coils, heavily varnished. Precision flush-surface rotor. Match-fitted bearings and large oil reservoirs. 3 mounting studs or resiliently mounted base.

and 4 HIGH-OUTPUT



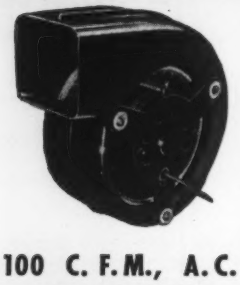
220 C. F. M., A. C.
3901 BLOWER
WITH DOUBLE OUTLETS

Accurately balanced 4¾″ wheels. Powered by a quiet 4-pole Micromotor. Heavy gauge steel construction. Micromotor resiliently mounted to blowers. Inlet screens and strong outlet mounting flanges can be supplied.



150 C. F. M., A. C.
3866 BLOWER
WITH SINGLE OUTLET

Powered by a smooth running resiliently mounted long-life 4-pole Micromotor. Carefully balanced 5¼″ wheel. Extra strong heavy gauge steel construction. Mounting flange for outlet available. Inlet screen can be furnished.



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Compact Micromotor-in-wheel construction. Balanced 5¼″ vibration-free wheel. Cool running 4-pole Micromotor mounted on resilient rubber for smooth quiet operation. Outlet mounting flange and inlet screen available.

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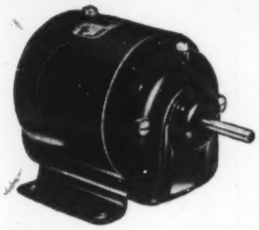
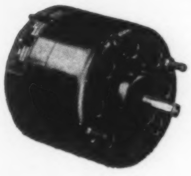


1/30th H. P., A. C., TYPE BT

2-POLE SHADED POLE

3000 R.P.M.

Totally enclosed die cast case. Air-Stream enclosed fan cooling. Varnish dipped long-life coils. Pressure cast precision rotor. Match-fitted bearings and high capacity lubrication. Resiliently mounted base, or 2 mounting studs.

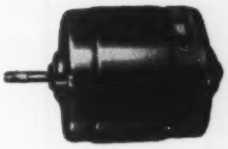


1/40th H. P., A. C., TYPE BL

2-POLE SHADED POLE

3000 R.P.M.

Heavy gauge drawn steel case, open ventilated. Pressure cast, precision skewed rotor. Long-life, humidity and oil resistant windings. Extra capacity felt packed oil reservoirs. Individually fitted self-aligning bearings.



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Topics

MAGNETIC REED escapement for watches and clocks will be exhibited at the British Industries Fair. Cheaper than the usual lever escapement of the pin pallet type, the reed is almost inaudible in operation and its timekeeping is four to five times better than that of ordinary escapements.

LOW-TEMPERATURE laboratory for research work at temperatures close to absolute zero has been completed recently by the General Electric Co. at Knolls near Schenectady. Now covering the range from room temperature to within one degree of absolute zero, the laboratory will before long be able to come within one-tenth degree absolute if required.

SKY COMPASS for aircraft use has many advantages over other direction instruments according to Joseph B. Matthews, Bureau of Aeronautics, Navy Department. Utilizing polarized light from the sky, the new compass is operable in polar regions during twilight if the weather is favorable.

TWO GRADUATE SCHOLARSHIPS, awarded annually by the Society of Naval Architects and Marine Engineers, are available to candidates with a graduate degree in some phase of engineering applicable to the marine industry. Applications should be filed with the society's secretary at 29 West 39 Street, New York City, before April 15 for the academic year 1949-1950.

SPANWISE LOAD distribution in airplane design has become increasingly important with the advent of thin swept-back wings in subsonic, transonic and supersonic aircraft. Thinness of the knife-like wings present engineering problems of how to make them strong enough to take the stresses of supersonic flight.

ACCELERATION EFFECTS on the dynamic characteristics of thin wings in transonic and supersonic flight decreases the drag in proportion to the square of the acceleration, report C. S. Gardner and H. F. Ludlof of New York University, although in the sonic range even small accelerations have very considerable influence on aerodynamic characteristics. Results of the investigation were discussed at the recent IAS annual meeting.

CIRCUITS for exceedingly small conductive or resistive networks for miniature electronic tubes are now being produced photographically by a process developed by the Kenyon Instrument Co. Patterns with a dimensional accuracy of 0.0002-inch are produced by transferring a photographic image to desired base, dissolving image and replacing it by a noble metal or material of characteristics desired.

PHOTOGRAPHS may be reproduced on metal, wood, cloth, leather, plastics or almost any other surface by a new process using an emulsion developed by the Glenn L. Martin Co.

GALLIUM, a rare silvery-white metal of unique properties, is being produced in limited quantities by Aluminum Co. of America. A liquid above 86 F, the metal will not boil until heated to approximately 3700 F. It has a density of 5.9, expands on solidifying, and wets many types of nonmetallic surfaces such as glass and porcelain.

PAPER CONSUMPTION in the United States for last year was 350 pounds per capita. Less than one-half pound per person was used in China where the art of paper making originated centuries ago. Yet China has as many people employed in making paper as does the U. S., according to Kenneth D. Lozier of St. Regis Sales Corp.

PROTECTIVE COATING system, based on vinyl and other plastic resins, is able to withstand the effects of even the most severe acids, chemicals and salts for long periods of time. Developed by C. A. Woolsey Paint & Color Co. for application to all metals, the finish is unaffected by temperatures of 200 F and may be applied by brush or spray at room temperature.

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There are three new grades of C-D Dilecto* that can withstand temperatures as high as 250°C. They are chemically inert, silicone-glass laminated plastics that offer exceptionally high heat resistance and good arc resistance, extra strength, and positive moisture resistance! At Continental-Diamond we've literally lived and worked with Silicone Dilecto—perfecting it to a point where we believe it can be highly useful in helping to solve your production problems — and improve product performance.

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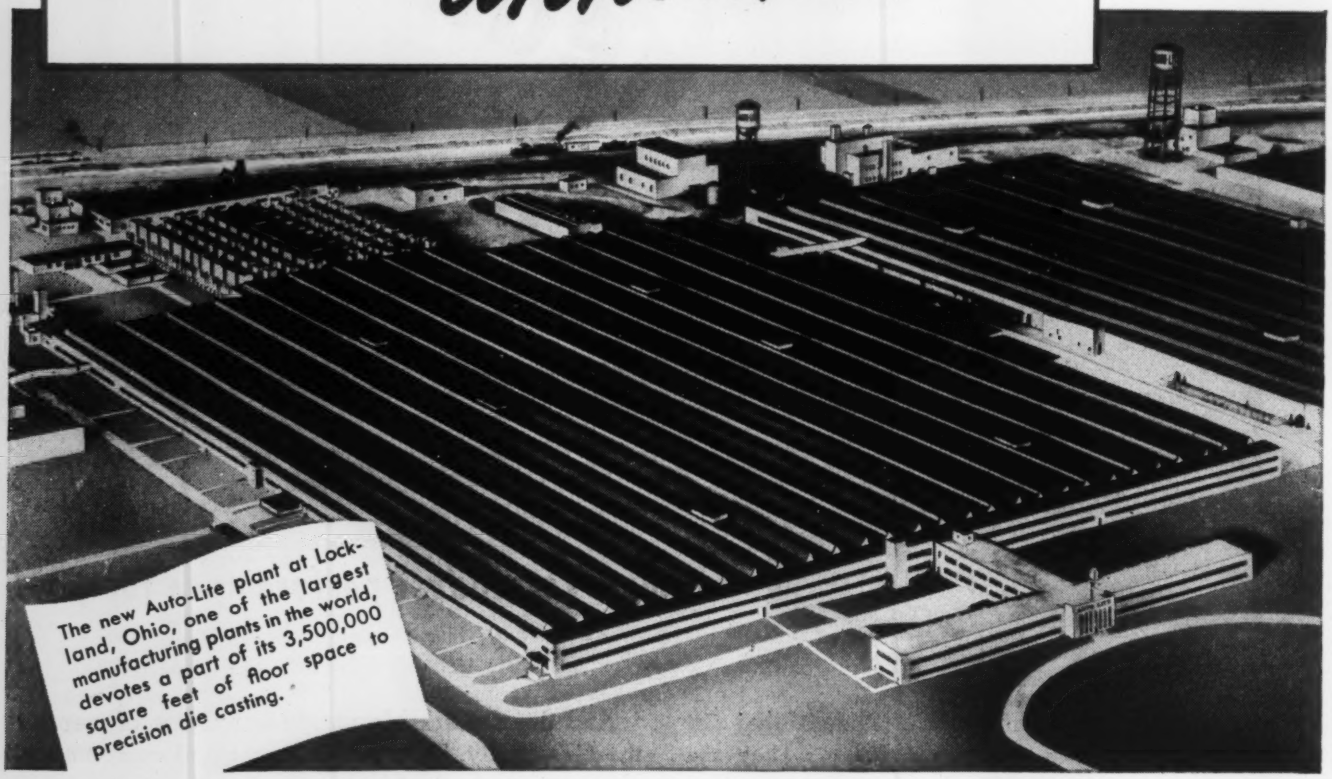

The new Auto-Lite plant at Lockland, Ohio, one of the largest manufacturing plants in the world, devotes a part of its 3,500,000 square feet of floor space to precision die casting.

Increased production facilities for

DIE CASTINGS

● Here is important news for everyone who has need of the accurate, reliable die castings made possible with the famous Auto-Lite "controlled metals" processes. The opening of the great new Lockland plant of Auto-Lite, combined with the enlarged facilities at Woodstock, Illinois, greatly increases Auto-Lite's ability to furnish the high quality die castings for which the Auto-Lite name is known wherever die castings are used. We invite your inquiries.

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MACHINE DESIGN

Discovering and Developing Creative Engineers

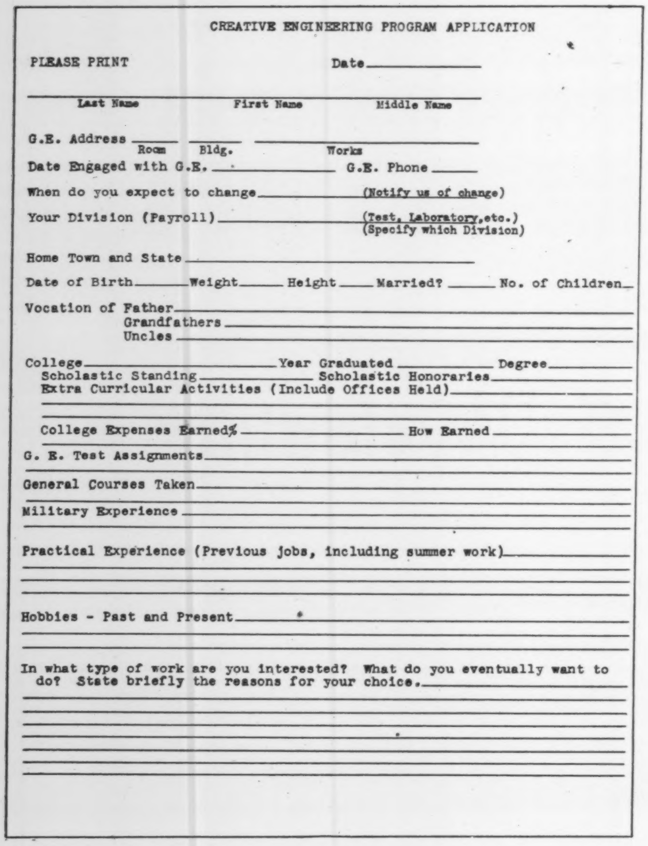
By Lauren W. Guth

Supervisor, Creative Engineering Program
Technical Education Division, General Electric Co.

POSTWAR expansion and competition in most industrial fields has brought increased demands for engineers with creative ability. Although the number of people possessing this spark of inventive ability is limited, too often they are left unrecognized and under-developed. Most authors on the subject of creative ability seem to agree that it is a quality born, not instilled, in an individual.

Our effort in the field of developing inventors is analogous to our endeavor to create diamonds. So far, we cannot compare with nature's ability to produce large, flawless stones—but we can and do find natural diamonds. Then by carefully planned pro-

Fig. 1—The author (left) and Harold Harle, supervisor of the first year class, interview an applicant for the creative engineering program



CREATIVE ENGINEERING PROGRAM APPLICATION

PLEASE PRINT Date ________

________ Last Name First Name Middle Name

G.E. Address ____ Room ____ Bldg. ____ Works

Date Engaged with G.E. ________ G.E. Phone ____

When do you expect to change ________ (Notify us of change)

Your Division (Payroll) ________ (Test, Laboratory, etc.) (Specify which Division)

Home Town and State ________

Date of Birth ____ Weight ____ Height ____ Married? ____ No. of Children __

Vocation of Father ________
Grandfathers ________
Uncles ________

College ________ Year Graduated ____ Degree ____
Scholastic Standing ____ Scholastic Honoraries ____
Extra Curricular Activities (Include Offices Held) ________

College Expenses Earned% ________ How Earned ____

G. E. Test Assignments ________

General Courses Taken ________

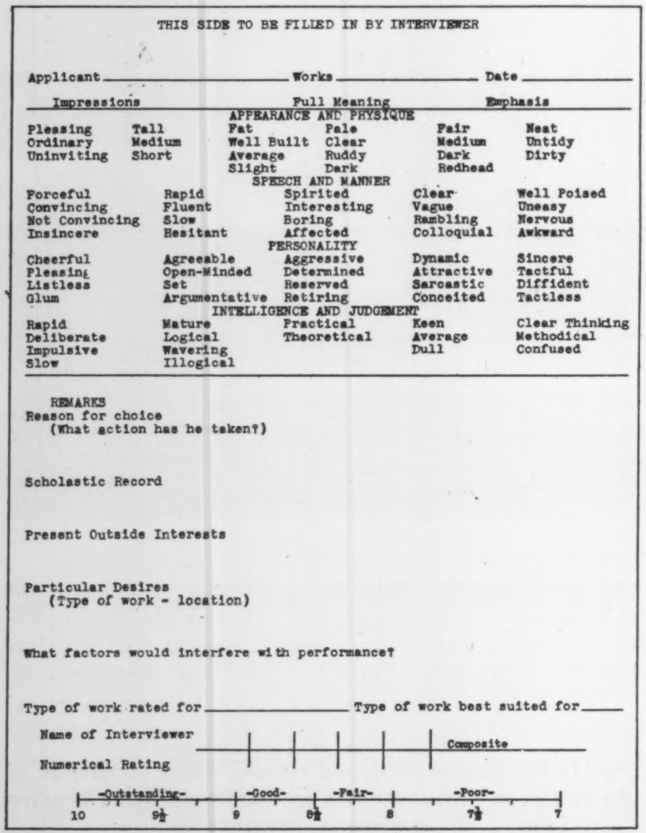
Military Experience ________

Practical Experience (Previous jobs, including summer work) ________

Hobbies - Past and Present ________

In what type of work are you interested? What do you eventually want to do? State briefly the reasons for your choice. ________

Fig. 2—Front (above) and rear (below) sides of application form used as a guide in conducting interviews and in rating applicants of creative engineering program



THIS SIDE TO BE FILLED IN BY INTERVIEWER

Applicant ________ Works ________ Date ________

Impressions Full Meaning Emphasis

APPEARANCE AND PHYSIQUE

Pleasing	Tall	Fat	Pale	Fair	Neat
Ordinary	Medium	Well Built	Clear	Medium	Untidy
Uninviting	Short	Average	Ruddy	Dark	Dirty
		Slight	Dark	Redhead	

SPEECH AND MANNER

Forceful	Rapid	Spirited	Clear	Well Poised
Convincing	Fluent	Interesting	Vague	Uneasy
Not Convincing	Slow	Boring	Rambling	Nervous
Insincere	Hesitant	Affected	Colloquial	Awkward

PERSONALITY

Cheerful	Agreeable	Aggressive	Dynamic	Sincere
Pleasing	Open-Minded	Determined	Attractive	Tactful
Listless	Set	Reserved	Sarcastic	Diffident
Glum	Argumentative	Retiring	Conceited	Tactless

INTELLIGENCE AND JUDGEMENT

Rapid	Mature	Practical	Keen	Clear Thinking
Deliberate	Logical	Theoretical	Average	Methodical
Impulsive	Wavering		Dull	Confused
Slow	Illogical			

REMARKS
Reason for choice
(What action has he taken?)

Scholastic Record

Present Outside Interests

Particular Desires
(Type of work - location)

What factors would interfere with performance?

Type of work rated for ________ Type of work best suited for ____

Name of Interviewer
Numerical Rating
Composite ____

-Outstanding- -Good- -Fair- -Poor-
10 9½ 9 8½ 8 7½ 7

cedures the many facets are added to transform the stone into a dazzling jewel. The value of the product is dependent upon the purity of the raw stone and the ability of the cutter.

Unfortunately, creative ability cannot be described as definitely as we can enumerate the properties of a diamond. Like most human traits, it eludes strict definition and establishment of limits. However, we can obtain a better understanding of this characteristic by a study of individuals known to be creative engineers. An appreciation of the qualities of a creative engineer, naturally, must be the basis for any program striving to develop such talent. Therefore, some of these qualities will be reviewed before discussing the processes for discovering and developing them.

What Makes a Creative Engineer?

Aptitudes of Creative Engineers: From the many articles written on creative engineering and invention, a list of aptitudes generally found in individuals possessing this ability would include the following:

1. Good reasoning power that is based upon a firm foundation in engineering fundamentals. This is more than the ability to make the mechanical manipulations of solving formulas; rather it means the ability to grasp the physical significance of formulas and the laws of science.
2. Keen interest, not only in his own particular field of engineering, but also in the broad aspects of science as a whole. It is by drawing from this broader knowledge and interest that he can contribute in the expansion of the horizon of his own field.
3. An active curiosity that keeps his mind delving into the why, how, and what of the old and new devices and phenomena encountered.
4. A constructive discontent manifested by a continual search for new and better ways of accomplishing desired results.
5. An organized mind able to catalog and file away for future reference the countless facts, phenomena, and devices encountered in daily experience. This is the storehouse of ideas from which new devices can be synthesized.
6. A practical and creative imagination, able to project past experience and present knowledge into new forms.
7. Sound confidence in himself and perseverance in his efforts to bring forth improved and advanced ideas and inventions.
8. The ability to bring forth new ideas by virtue of his reasoning powers and intuition. He cannot only create the new idea, but can also carry it through to a practical device.

Discovering Creative Engineers: When faced with the problem of selecting engineers with creative ability, the foregoing aptitudes should be considered. The creative engineering program, an educational activity of the General Electric Co., has adopted a combination interview, *Fig.* 1, and examination technique for selecting members. The present method is the result of over ten years of experimentation and

MEET THE AUTHOR

LAUREN GUTH, a graduate of Drexel Institute of Technology, spent four years in the army, emerging as a captain in the Signal Corps. He joined General Electric in 1946, entering the company's test program. After six months on test he was enrolled in the creative engineering program from which he graduated last year. At present he is in charge of the program, his title being Supervisor of Creative Engineering Program, Technical Education Division.

evaluation. About one out of six who submit applications are selected for the program.

Conducted in an informal and friendly manner, the interview is guided by the interviewer through the information on the application form, *Fig.* 2. Prior to the interview, the interviewee has supplied a list of his hobbies, organizations to which he belongs, past engineering and business experience, military experience, etc. He has also been asked to state the type of engineering position he would like to attain and the reasons for his desire.

One strong indication of creative ability can be obtained from the applicant's past experience in hobbies in which he made things with hand or power tools. Absence of creative hobbies is a good indication of the lack of creative engineering ability. On the other hand, manual dexterity is not necessarily the mark of an inventor. A number of the devices that the applicant has built are recreated in the interview. It is essential to reconstruct the situation—the thinking, operating principles, fabricating methods, and the evaluation of the results. Care is employed to determine how much individual and collective effort was involved.

Details of any designs presented are ferreted out. On one occasion an applicant for the creative engineering program described a starting-cord rewind device for an outboard motor. The mere fact that the device was then in common use was not, nor should it have been, considered to indicate lack of "invention" on his part. However, even with prompting, he did not remember the need for some kind of clutch mechanism to free the cord from the motor driveshaft after the motor started; nor could he suggest a method when the need was pointed out. This, and subsequent information, tended to indicate past contact with inventors rather than creative ability.

New methods, materials, and devices are introduced to permit the applicant to express his ideas. One approach is to ask how common devices work, i.e., a differential, toggle switch, or the new automatic cutoff arrangement on gasoline pumps. His ability to express himself, organize his thoughts, and make sketches are revealed during this form of interview. The applicant is encouraged by all means to express his ideas in details for the interviewer to study and evaluate. When the answers seem to be previously prepared to influence the interviewers, prolonged questioning usually will exhaust the preplanned portions and reveal true abilities. The time involved depends upon the skill of the interviewer to draw out the applicant.

The second phase of selection used in the creative

Fig. 3—Below—First-year class in creative engineering in session with first-year supervisor Harold Harle at blackboard. Harle is second-year student in program

engineering program is the four-hour entrance examination. This is conducted independent of the interview, because a comparison of the results is not valid if the interviewer has been influenced by the examination mark. As in the interview, only minor emphasis is placed on analytical ability. The examination is designed with a definite time limit on each question to assure that the applicant's reactions can be evaluated for every part of the examination.

Aptitudes of a creative engineer, as earlier summarized, suggest subjects for the written test. Some of the problems are inventive in nature as: (1) Design an automatic pea sheller; (2) design a nondestructive test for the vacuum in a coffee jar; (3) suggest improvements for an automobile. By having the design sketched, explained, and evaluated on the answer sheet, the results show the person's aptitude on such creative problems. By this means a fair comparison between individuals in a group of applicants can be made, since the examination conditions are more uniform for each individual than would occur in an interview.

Another phase of the examination is designed to reveal design sense and perception. One highly successful problem of this section is that of sketching a bicycle. Surprisingly, it is rare indeed to find a near perfect drawing. Proportion, attention to mechanical details, sketching ability, etc., are all displayed in the one sketch. Another task given may be to indicate by circles the relative size of round stock of various kinds of material, such that each rod has the same given tensile strength. From questions like these, and descriptions of how common devices work, design sense, ability to assimilate facts and phenomena, and sketching techniques can be studied.

In the technical or analytical portion of the examination, the purpose is to test the reasoning power of the applicant. His understanding of fundamentals is more important than the formulas he can remember. Perhaps he may be asked to design a spring. Formulas involving the parameters, such as number of turns, wire diameter, spring modulus, etc., would be given. He would be required to assume certain values and by cut and try methods develop a design that looked reasonable. In this manner he reveals

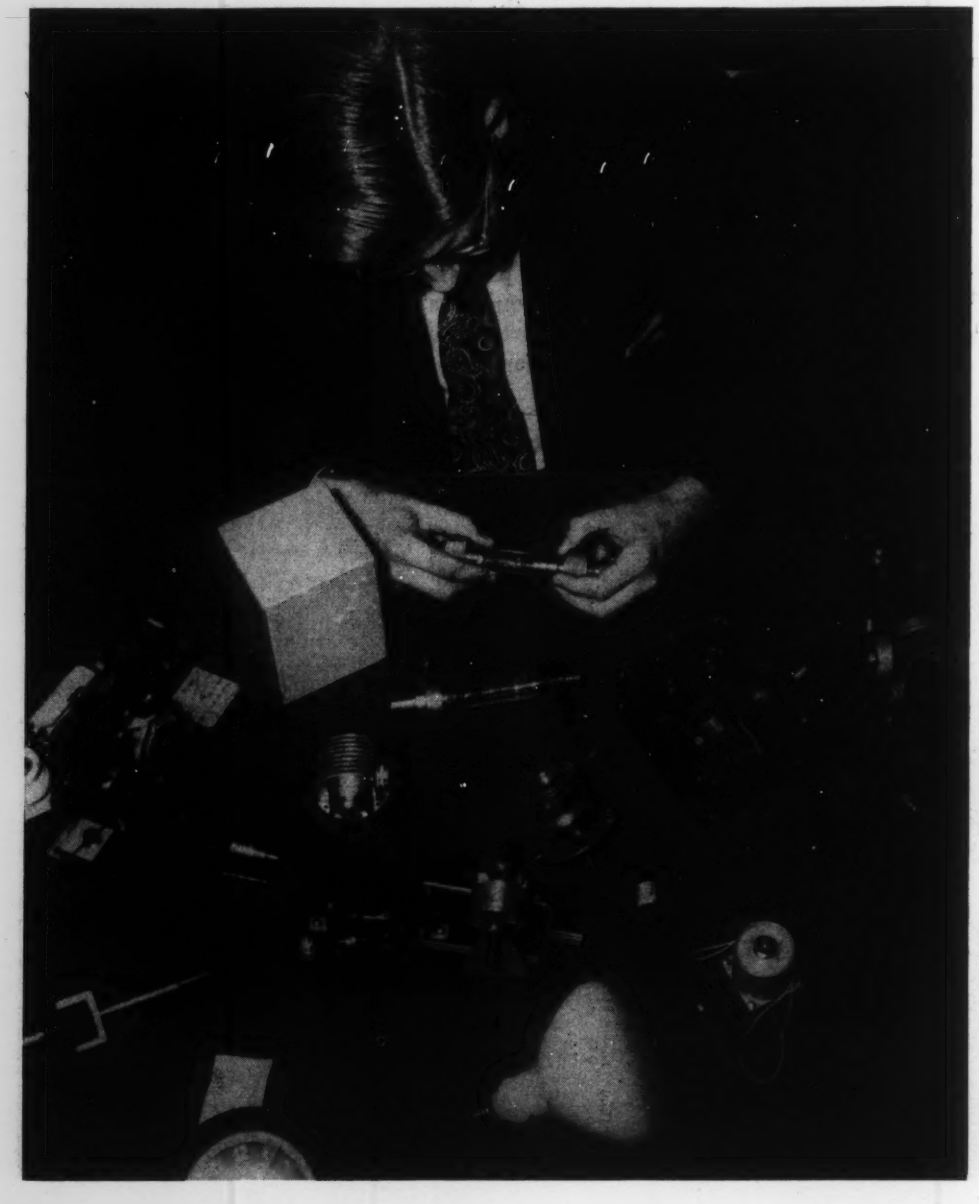


Fig. 4—The author looks over some of the work done by students in the creative engineering program. These devices are only a few of the many now in process

his ability to combine mathematical relationships and common sense to produce a practical design.

Results of the examination and interview are weighed together for the final decision, with proper appreciation of the applicant's past history. On comparing two individuals, proper thought should be given to relative maturity and past opportunity to broaden knowledge. If he really has creative ability, an engineer with a few years of design experience should be superior to a recent graduate. On the other hand, the many factors that are involved still leave these methods far from perfect, but they do serve to make a more positive selection. Surveys conducted at General Electric show that the selections made by the procedures described have been successful to a high degree.

DEVELOPING CREATIVE ENGINEERS: Having screened a group of young engineers for those exhibiting creative ability, there arises the real problem facing industry; namely, how to develop and utilize this ability. Procedures followed can be the same for a large company as for a small company. The only difference need be in the numbers involved and the breadth of activity as determined by the diversity of products of the concern. For example, the General Electric Co. operates a rather extensive program for developing creative engineers for all departments of the company. On the other hand, the Parts Development Works of the company's Lamp Department (an engineering group comparable to a small company) has been successfully conducting classes to develop creative talents more specifically applied to the design of automatic machines. Thus, the size of the group need be no hindrance.

Program Must Not Be Static

Fundamentally important to any educational endeavor are the individuals who frame the policies and philosophy of the course. The program must not be confined to a rigid pattern. Nor should the ideas be limited to those of one engineer. Techniques used by many engineers should be discussed so the students can better evolve processes that harmonize with their own individuality.

Two main phases comprise the creative engineering program: class training and rotating assignments. Every engineer selected participates in two years of rotating assignments and at least one nine-month period of classes. A second term of class training is provided for the top two-thirds of the first-year class. Classes are held one morning per week on company time, *Fig*. 3.

The rotating portion of the program consists of an organized series of assignments on engineering work under the direction of senior engineers acknowledged to possess creative ability. In the course of a two-year period, each young engineer works on seven or eight assignments in turn. The engineer to whom he is assigned supervises his work and takes special care to develop stability and unity through discussion and personal example. Insofar as possible, the young engineer is given complete responsibility for the design of a device so he may gain the experience and confidence essential to a productive career.

This is similar to the method of apprenticeship but has several important differences. The number of assignments makes it possible to have each man work on several different products and in several different fields, and thus assures an opportunity for a "non-habitual approach." Assignments also vary from pure development to design for mass production. When possible, as the engineer gains experience, he is given increased responsibility and decreased guidance so that he will learn to depend upon himself. Perhaps even more significant is the supervision by several different senior engineers. Much as an artist is developed by association with a master, so the creative engineer develops in his work with the senior engineer. Close contact with a number of these men allows him to gain inspiration and technique from all, without the danger of losing his individuality in the tendency to emulate any one of them.

Leaders Picked from Within Program

Classes are supervised by young graduates who devote full time to the work. This provides an excellent opportunity to develop qualities of leadership in the few who can be given this privilege and assures a close relationship with the needs and ambitions of the class members. Whatever time the supervisor has to spare is spent on engineering problems as a consultant to the juniors.

Main theme of the first-year class is the conception of new ideas. Considerable emphasis is placed upon understanding the fundamentals of physics which underlie engineering. Subjects covered include dynamics, materials and processes, electric circuits, electric machinery, basic electronics, and also

Fig. 5—Ben Horvay, a first-year student, examines the adjustable, magnetic pressure-cooker valve that recently won him his first patent

human relations. Lectures on these topics are given by experienced engineers of the company. Many of the lectures cover the broad aspects of new fields such as atomic energy, gas turbines, and instrumentation. Talks of this kind create interest in new lines of endeavor. Self-confidence and a desire to create are stimulated by seeing how a little inspiration and a lot of persistence can produce almost unbelievable results. It is shown that real progress in engineering often results from projecting practice ahead of theory and then bringing theory up to date. Likewise, failures from unsound application of engineering fundamentals are presented as a note of caution.

Problem-Solving Methods Differ

Throughout the course, techniques or processes for solving problems are continually brought to the students' attention. No set method is proposed as the best for any individual. Instead, leading inventors are invited into the class to describe their experiences in creating new devices. Many of the young engineers have a strong tendency to "get the answer" before really defining the problem. The relatively few parameters involved in the textbook problem probably create a false impression that it is not necessary to make a full investigation of the conditions before attempting a solution.

Home problems requiring twelve to fifteen hours are assigned each week. Approximately one-fourth of these are to emphasize the study of fundamentals. The other three-fourths deal with new devices or modifications needed by the company's engineering departments. Real problems of this type stimulate creative thinking and the "nonhabitual approach," and help each young engineer to develop a technique of synthesis to fit his own individuality. Results of these design problems are often influential in the solution of some of the company's problems.

Problem solutions are written as engineering reports to develop proficiency in presenting ideas. These reports are constructively criticized for technical excellence, originality, and presentation. Longer problem assignments and overlapping assignments help make it possible to get answers to every problem assigned and, in that way, give the engineers confidence in approaching any new problem. Sometimes solutions are evaluated in class seminars led by a representative from the interested engineering department. Such discussions enable the young engineer to see the problems from various aspects and in the light of different practice and principles.

A good portion of the class time is spent in inspection of manufacturing departments. These trips are augmented by talks by shopmen for answering questions and bringing out important points. In this way the young engineers' knowledge of materials and factory processes is furthered. Other subjects covered in the classroom period include informative talks on various phases of engineering, company policy, patent law, and training in freehand sketching which is a valuable tool in design work.

During six weeks of the classes each man works on one inventive design project of his own selection as his homework. Those who wish to construct working samples of their design in their spare time use the various engineering divisions' model shops. Some time early in 1949 the program will have its own large, well-equipped development shop. These projects, *Fig.* 4, are good indicators of the direction as well as the magnitude of a man's ability. A high percentage of these projects result in models that demonstrate patentable ideas. This was the case with Ben Horvay's magnetic pressure cooker valve, *Fig.* 5.

The second-year class continues the work of the first year but places the emphasis on reduction of new ideas to practical design for manufacture. Home problems are, likewise, actual engineering problems from the design divisions. More detailed and complete results are expected from the second-year men. Efforts are made to supply models of the solutions wherever possible.

More advanced technical courses are studied in the second year. Advanced machine design centering around automatic machines includes such topics as kinematics, spring design, bearings, etc. A course in servomechanisms is covered in an eight-week period of two hours per week. Other subjects studied are heat transfer, differential equations, and hydraulic systems. Throughout the technical studies, practical application of fundamentals is the prime object. Highly theoretical analysis is not pursued.

Much of the class time is devoted to talks by experts in the various fields of design and manufacturing. Cost of fabrication, engineer-factory relations, cost reductions, planning, and factory tolerances are typical subjects for lectures and discussions. All tend to indicate how good design will result in a high quality product that can be sold at a competitive price.

EFFICIENT UTILIZATION OF CREATIVE ENGINEERS: Whether or not a formal training course is provided, the creative engineer should be placed in a position where his abilities can be used to full advantage. He should be given all the responsibility he is capable of taking so that he will have maximum opportunity to exercise his ingenuity. When possible, he should be relieved from the tasks of routine or "paper work" nature.

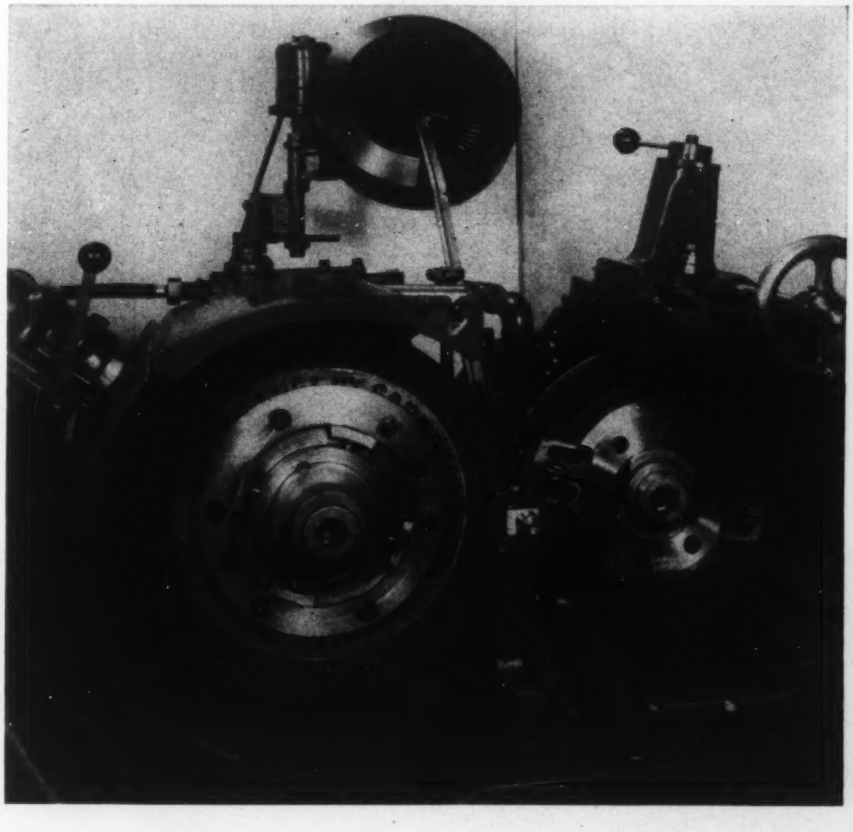
Proper Working Conditions Imperative

The atmosphere of the job should permit and encourage expression of opinions and new ideas. He should not be stifled by the type of leader who only wants to consider his own ideas. A team consisting of creative engineers who are experts in different lines might be advisable to produce the collective genius essential to many development programs. Any grouping of creative engineers must be made with due consideration of the compatibility of the individuals involved.

Adequate model-shop and experimental facilities should be available to the engineer. A small allowance of money for development of ideas, not directly connected with a given job, can be a source of

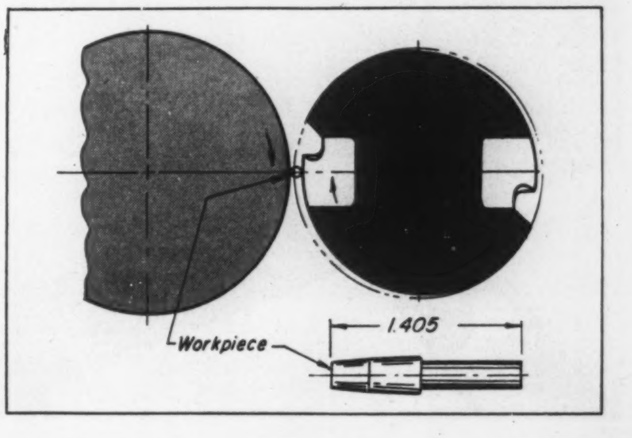
(*Concluded on Page* 191)

Scanning the field for Ideas



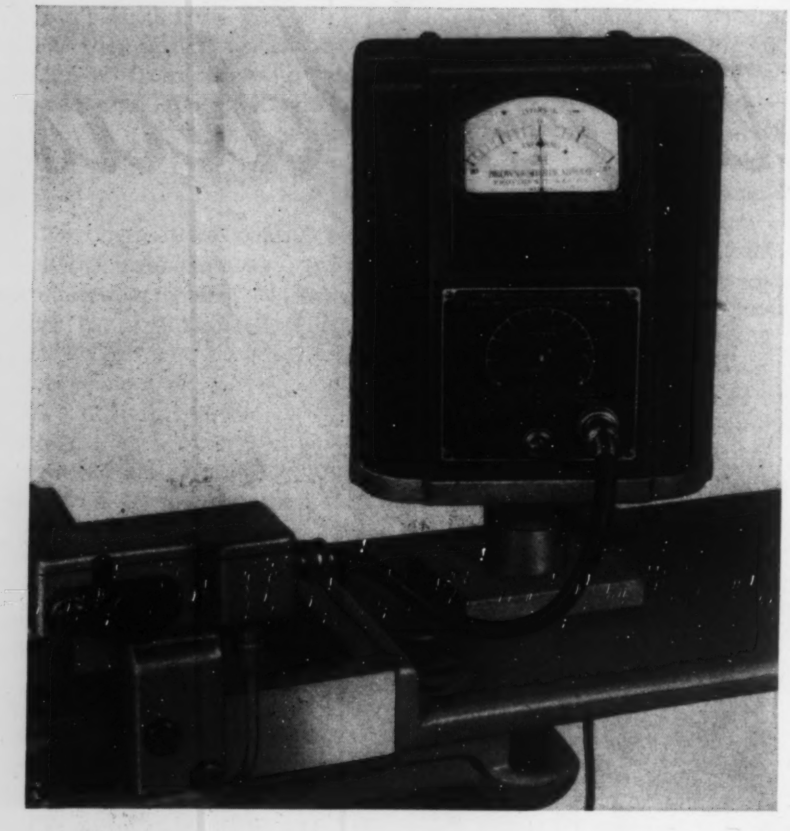
Regulating wheel on the Cincinnati centerless grinder, right, has a trued periphery in the shape of a cam. In this way a rotary infeed effect is obtained without movement of the slide to feed the work to the grinding wheel. In the setup illustrated the regulating wheel has identical cam shapes trued on two sections as shown in the sketch at right below. Notches in the metal inserts provide a simple and effective method of ejecting the finished pieces by gravity. This design, however, is primarily useful for grinding parts of small diameter and short length.

Fixed relationship exists between the regulating wheel and grinding wheel at all times because the slides on which the wheel housing is mounted are locked at all times. Little wheel wear occurs on the section of the regulating wheel which brings the workpiece to dimensional accuracy. Initial punishment always affects the same section of the wheel and takes place before the work reaches the finishing section. Automatic loading from a rotary type hopper assures that the work is fed at the proper angular position of the cammed wheel.



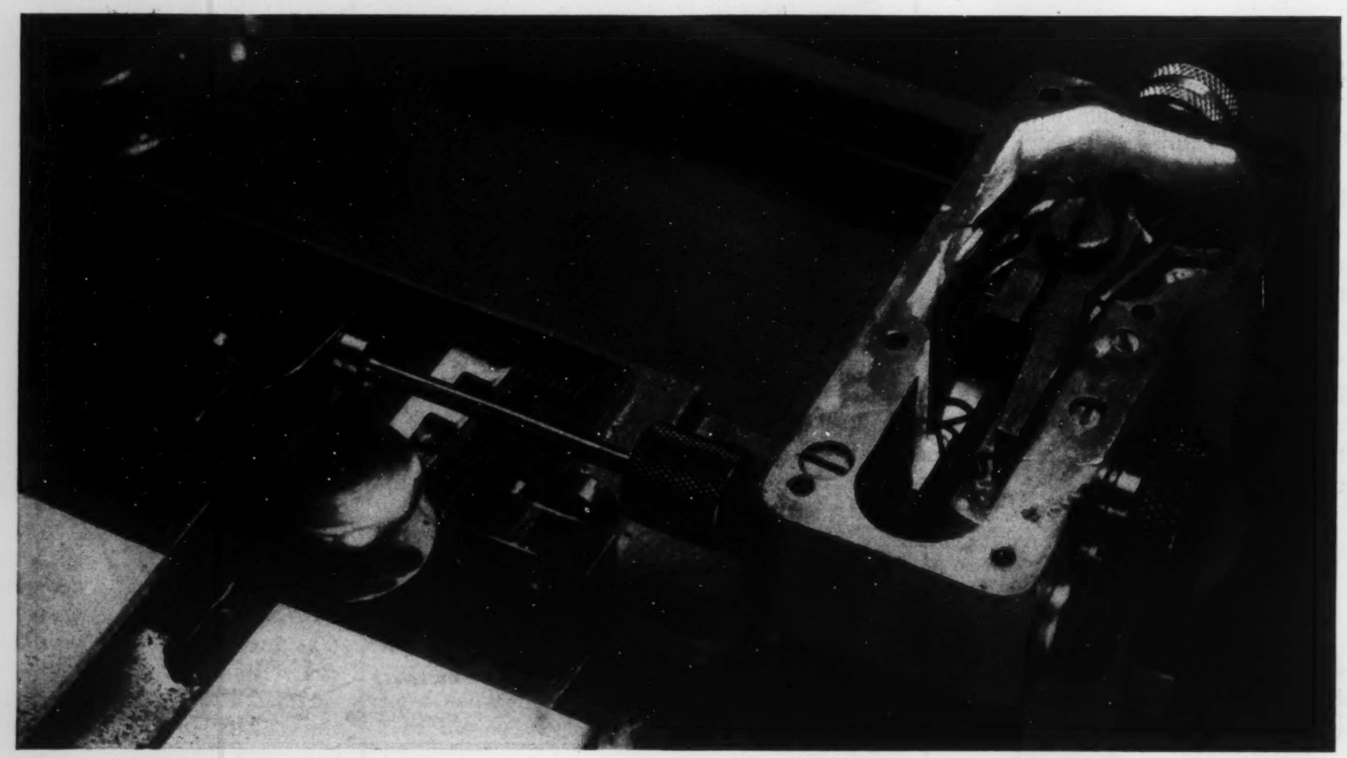
Strain gage measuring heads provide an accurate method of making a single and certain correction for measured error when grinding either a straight or tapered shaft. These heads are mounted on each end of the sliding table of the grinding machine and maintain spring contact with the swivel table. Signals are combined and amplified to give meter readings in 0.0001-inch increments as shown in view of amplifier unit below.

Since the angular movement of the swivel table relative to the sliding table is the basic value needed in setting, the measuring heads have been designed by the Brown & Sharpe Mfg. Co. to give direct measurements of this movement. In the past, machines have employed indirect indications of swivel movement. These required a perfect pivot having no clearance or deflection together with rigid table and adjusting members.

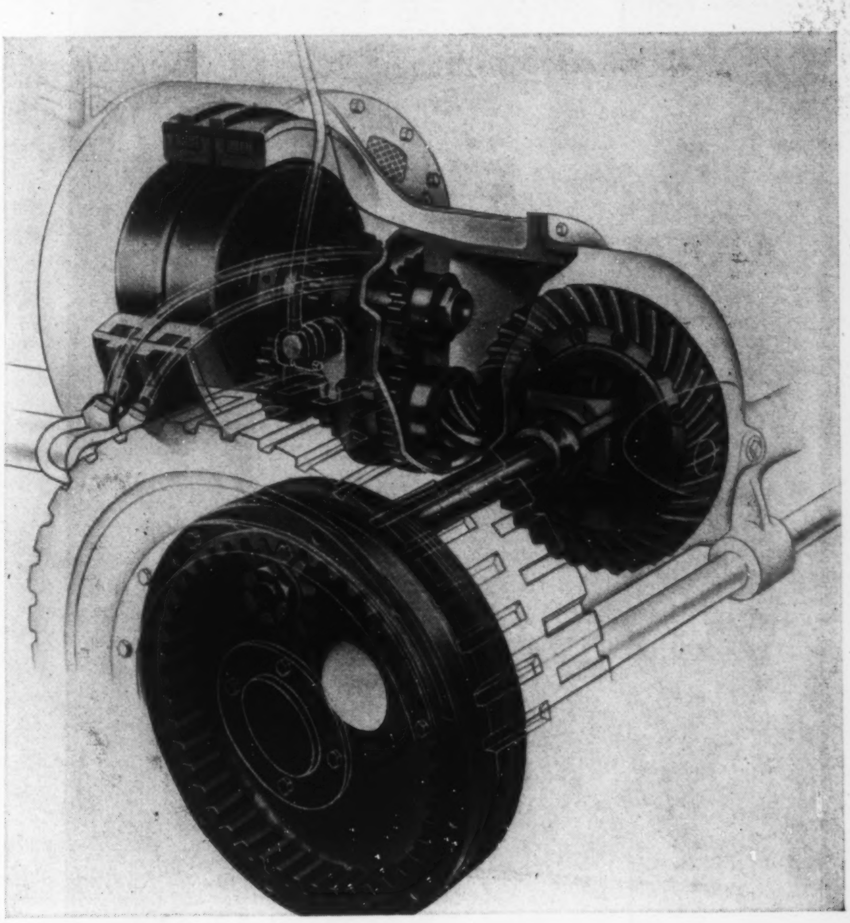


The measuring heads, below, employ sensitive SR-4 strain gages cemented to the sides of cantilever spring bodies. Deflection of the cantilever imposes tension or compression stresses in the gages, changing their resistance and unbalancing a Wheatstone bridge circuit. One of the useful characteristics of the SR-4 strain gage is that its change in resistance has a linear relationship with stress or deflection, making possible the interconnection of the gages at the table ends to give a composite signal.

To operate the amplifier, alternating-current power supply is transformed and fed to a direct-current rectifier. Part of the direct-current output of the rectifier supplies the anode power in the tubes. The remaining direct current is controlled by a gaseous regulator and converted to 1000 cycles per second. This audio-frequency power is supplied to the Wheatstone bridge and also to a phase discriminating copper-oxide rectifier to provide an amplifier of high power gain which will be insensitive to stray fields.



Strength of the signal from the Wheatstone bridge is varied by a potentiometer controlled by the position of a dial pointer on the amplifier unit. This selector is used so that the instrument will automatically indicate the error depending upon the distance between workpiece measurements.



Eddy-current clutches in the industrial truck transmission at right obviate the conventional mechanical clutch and reverse-speed gear shift. Developed by the Clark Equipment Co. for use on their fork-lift trucks, the drive is controlled by the operator through a simple three-position selector switch.

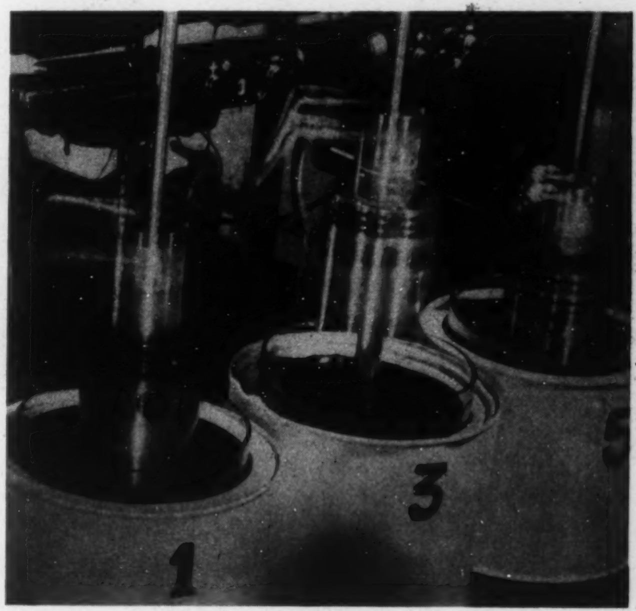
Two sets of magnetic coils are mounted within the flywheel and are surrounded by magnetic poles. They rotate with the flywheel and are the driving members. Two rotors, each controlled by one set of the coils and attached to forward-and-reverse constant-mesh gearing, are the driven members.

When the clutch coil for forward speed is energized by positioning the selector switch to "forward" position, a high-density magnetic field is set up between its rotor and the flywheel to transmit driving force through the constant-mesh gearing to the axle and wheels. Similarly, reverse speed is obtained by energizing the other clutch.

For inching operations which require slow and careful maneuvering, the torque transmitted by the clutches may be controlled by varying the voltage to the flywheel coils. This voltage is varied by an operator's foot pedal. Otherwise operation is controlled by the position of the accelerator pedal.

Piston temperatures may be measured in engines operating at 2000 rpm by a new method, right, developed at the Beacon, New York laboratories of the Texas Co. Former types of mechanical devices fail under high speeds, heat and reciprocating motion of the pistons, and cause formation of oil films on contacts which results in open electrical circuits.

This new technique employs air-cushioned plungers which contact at intervals a thermocouple placed inside the piston. Heat is determined by measuring the current induced by the thermocouple, no oil film being present. The thermocouple terminals are mounted on a holder which extends below the piston skirt. Plunger tips are installed in the crankcase to contact these terminals. A pushbutton valve induces air pressure behind the plungers, forcing them out into contact with the terminals at the lower portion of the piston stroke. After readings are taken the valve returns to its normal position, inducing a vacuum behind the plungers. The actual contact is wiping, eliminating formation of oil films.



Engineeri

How simple styling princ

By Carl Louis Otto
Partner
Raymond Loewy Associates

ENGINEERING may be an exact science, but the things that go on in a customer's mind are by no means exact. The finest machine will not sell unless the customer actually thinks and believes it to be the finest. There are certain basic effects which, however well done in an engineering sense, will poison the mind of the customer against a product and, correspondingly, other effects which appeal to him. It is the province of the designer to introduce into the machine as many appealing features as possible.

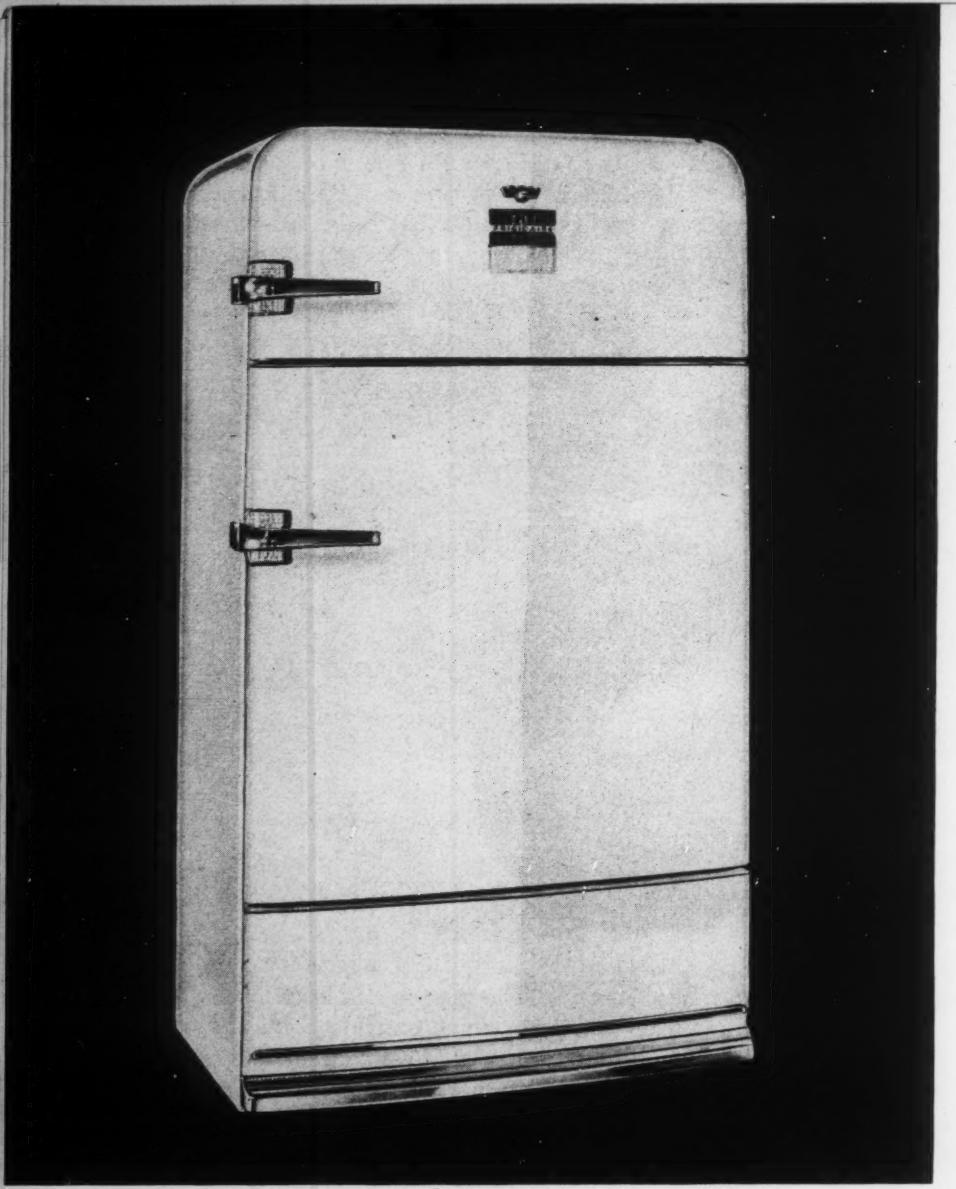


Fig. 1 — Above — Elimination of structural joints by shallow stamping the front members of this Frigidaire refrigerator results in enhanced unity of appearance and overall clean-lined styling

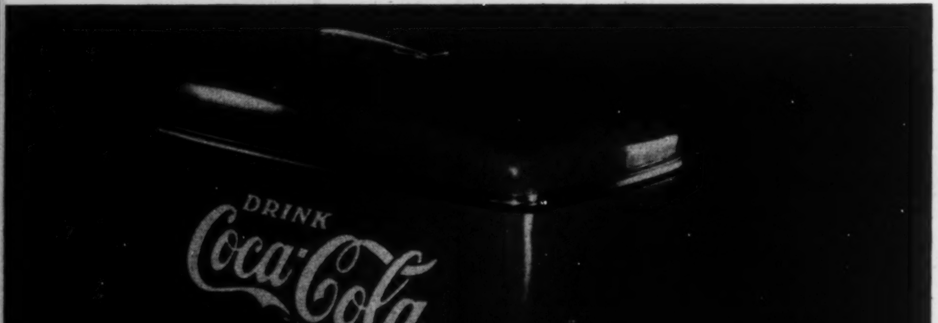
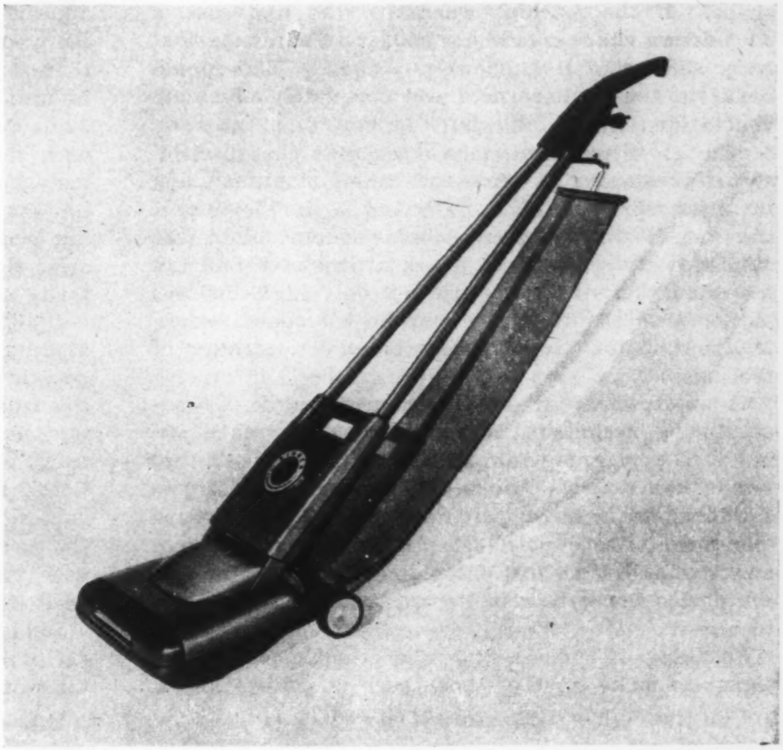


Fig. 2—Left—Where tool cost is warranted, deep-drawn housings can be used to effectively eliminate visible joints. In this soft-drink dispenser, ball corners and convex sides and top lend character, eliminate "boxiness" of appearance

ing by Eye

ples enhance sales appeal



Up-Grading: In his effort to appeal to the customer, the designer is actually endeavoring to *up-grade* the product. Take a hypothetical case—a medium-sized machine, housed in a metal cabinet on which are mounted controls and a nameplate. If the cabinet members were made on a press-brake, necessitating sharp corners and a multiplicity of lap joints near the edges, the result would be a primitive type of cabinet which does not impress the customer. The surfaces would not be truly flat and might "oil-can" either in or out so that the form would seem undernourished and flabby.

This design could be up-graded by having the front or formal side of the cabinet formed as a shallow stamping, *Fig.* 1, resulting in a refinement of shape and eliminating joints from the front face. If this were followed by adapting the shape of the cabinet to forming on a tangent bender, at least two large radii would be permitted in the corners, which would eliminate "boxiness" of appearance and modernize the

Fig. 3 — Above — New Singer vacuum cleaner departs from conventional floor type design to effect improved operating convenience, greater utility and modern appearance

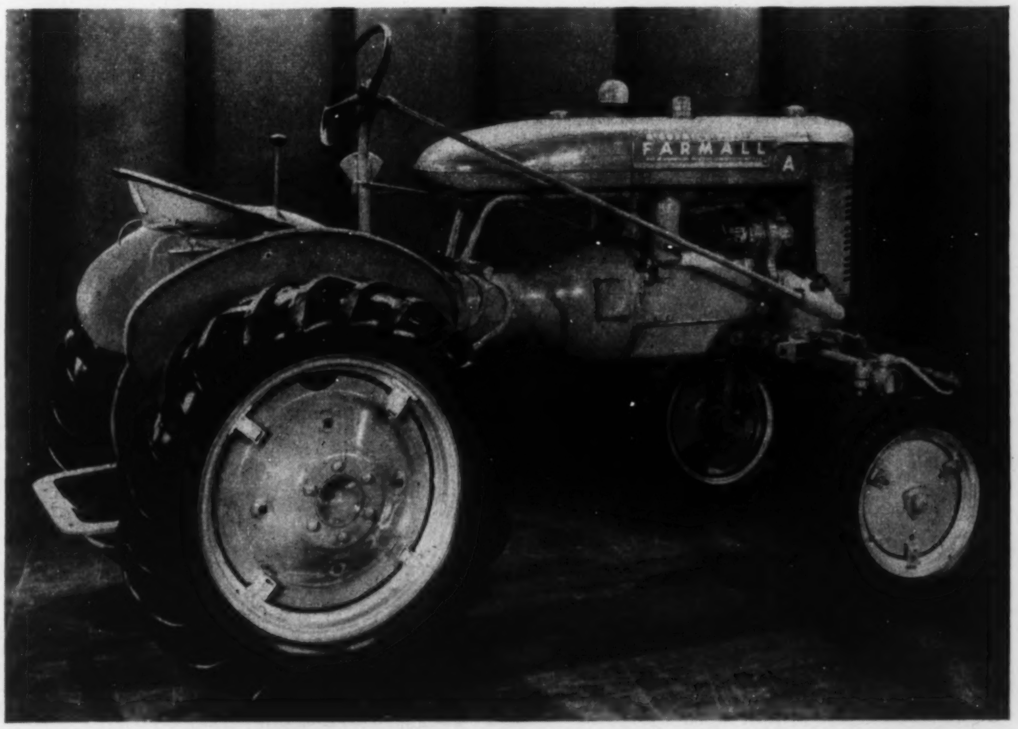


Fig. 4—Right—By adapting finish and styling details from the automotive field, the appearance of agricultural machines such as this Farmall tractor can be improved to increase their overall appeal to the customer

shape. If the machine warranted the tool cost, a deep-drawn shape could be considered for this cabinet body similar to that shown in *Fig.* 2. This would result in four ball corners and completely eliminate visible joints. By following this sort of progression so far as is practical, it will be seen that the designer is working towards the use of manufacturing facilities which offer more freedom in the shaping of the item with consequent elimination of joints. In almost every case these joints are objectionable to modern design—objectionable not only in themselves but because so often they require attendant fastenings and, in the case of spot welds, a deterioration of the finish.

It is noteworthy that progress up the scale of manufacturing technique is accompanied by enhanced unity of appearance. It should be remembered that when the customer shops for a product, he has a specific item in mind, thinking of the entire unit in one word or one idea. He is not interested in or aware of the sequence of components that enter into the device but rather in its appearance as it is sold to him.

Speaking of components, it is possible for the designer to make some of them, such as control knobs, appear to be more substantial, more valuable and more convenient than standard types and thereby turn them into sales features, *Fig.* 3. All components are by no means sales features. Therefore, it is up to the skill of the designer to emphasize those which count with the customer. Controls are mentioned in this instance because they are an ideal example of where to appeal to the customer. He not only sees them but actually tests the feel of them as well. On the sales floor they are much more important momentarily than the ultimate performance of the machine.

OIL-CANNING: Reverting to the hypothetical cabinet bent up on a press-brake, the next problem encountered is stiffening the panels. Beginning at the bottom of the scale, crossed miter lines could be formed in the sheets, giving a design character akin to the early threshing machines. Designwise, an attempt might be made to up-grade the machine by spot welding internal braces. If this interferes with the metal finish, beads could be formed in the panels with the proviso that they align as much as possible with the overall pattern required of the design.

Industrial designers are partial to more sophisticated modes of manufacture such as the use of the tangent bender which puts the metal under such

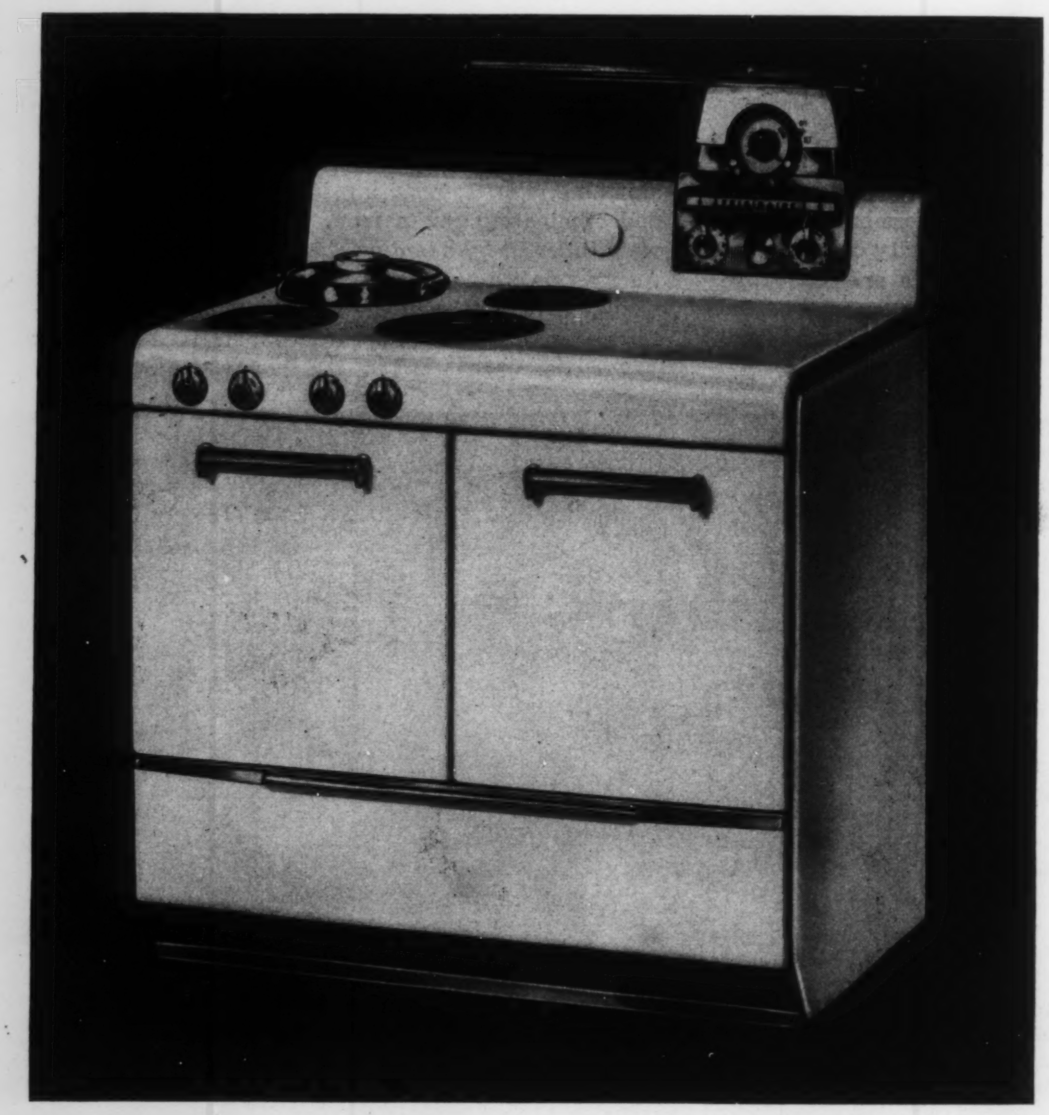


Fig. 5—Left—Combining top and front control-panel surface into one piece, plus rounded corners and elimination of joint lines, removes all vestiges of old-fashioned appearance and lends a feel of clean-lined solidity to this Frigidaire range

tension as to be its own brace, thereby giving the designer a clean surface with which to work. There is, of course, the limitation imposed by the fact that all the major radii of a tangent-bent shape lie in one plane.

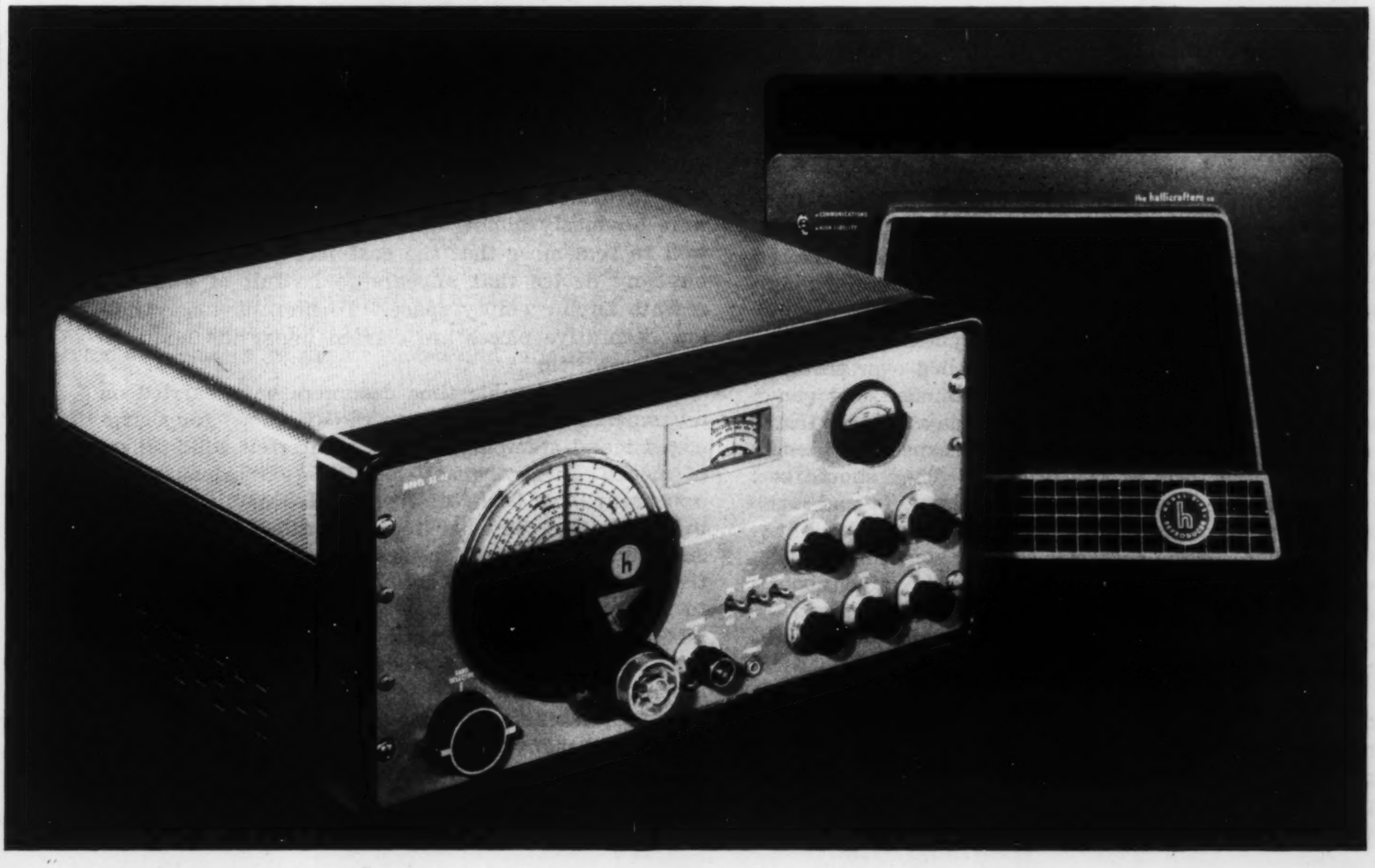
BALL CORNERS: Deep-drawn shapes are not always necessary nor desirable. Nevertheless, they do offer true ball corners where such are needed. It is the absence of this feature that makes the sharp-cornered press-brake job look cheap. The ball corner is a difficult problem with low-run production where elaborate tools are not available, although the tangent bender has come a long way toward making possible simple construction with satisfactory appearance. It can almost be said: "Take care of the ball corners and the form will take care of itself".

Having up-graded a product to the deep drawn stage, the designer sometimes asks for corner radii far smaller than the press shop would ever volunteer. This apparent conflict can best be explained by saying that a production engineer determines the size of the radii by the depth of draw in the piece whereas the designer determines the size of radii by the size of the totally assembled product. To achieve his effects, therefore, the designer must occasionally ask that changes be made which, from a pure engineering standpoint, may seem to have no real basis.

FINISH: Up-grading a machine can also be accomplished by improving the finish of all visible parts. As a rule of thumb, one can generally borrow ideas from an industry further up the scale of refinement. For example, a line of agricultural machinery, ***Fig.*** 4, could assimilate some elements of automobile finish and attention to design detail which would give the line more value in the customer's eye. Often a machine is too large or bulky to warrant an overall expensive finish, be it painted, enameled or plated. Nevertheless, the effect of high quality finish can be achieved by concentrating on certain areas, or on certain components, using the body of the machine merely as a background to show off a frankly expensive and pretentious nameplate or a magnificent piece of hardware. One of the outstanding successes in the refrigerator field before the war was a low-cost product which, however, incorporated in its design the most expensive hardware, nameplate and visible interior fittings in the industry. This was done on the basis of spending the money where it would do the most good saleswise.

EFFECTS: The desirable quality of "modernity" in appearance is an intangible, but to achieve it the things that should be avoided are fairly obvious. For example, many appliances and products look old fashioned as a result of their visual similarity to something out of the past. Metal housings and shapes having a joint near the top (particularly if the top overhangs the case) bring to mind the old kitchen table with its overhanging plank top. Thus, an item possessing this or similar characteristics, although

Fig. 6—Below—Attractive appearance has been achieved in this Hallicrafters receiver without resort to superficial trim. Well-proportioned shape, rounded corners, grouped controls and proper contrast in finish tones and textures add up to a forthright design of high quality



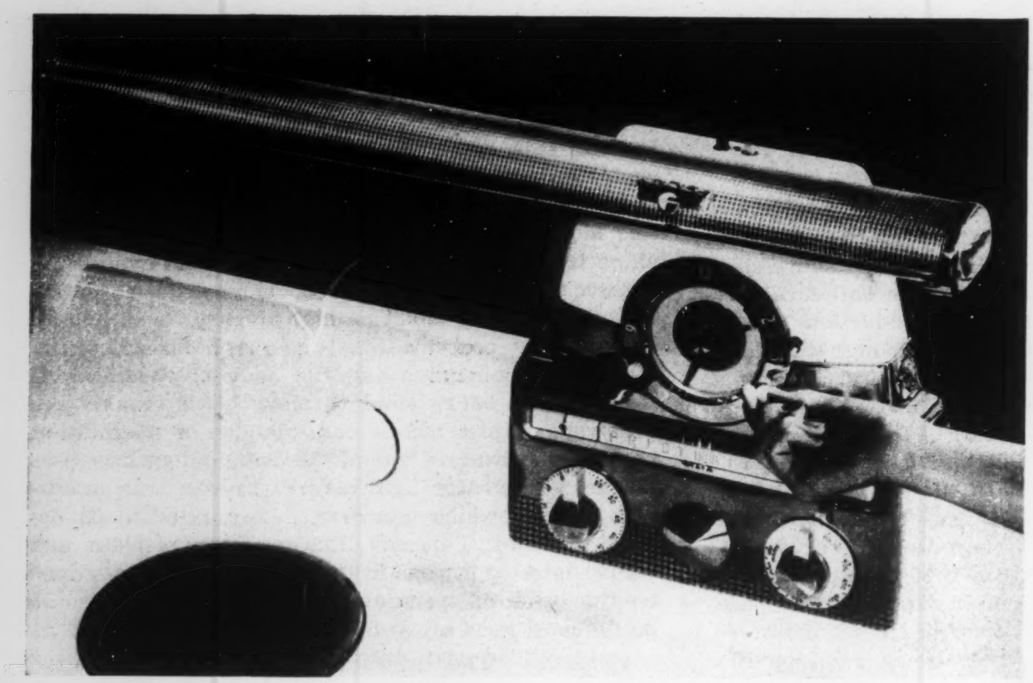


Fig. 7—Timer and oven heat controls of Frigidaire electric range are grouped and positioned conveniently in a unit which is distinctive and modern in appearance

soundly engineered, will produce a mental hazard for the customer. He does not know why, but the product does not look "up-to-date". Consequently, wherever possible, designers should try to avoid giving the structure any resemblance to an outmoded or inappropriate mode of manufacture. In no way does this invalidate the many cases where an overhang is essential. The designer, then, merely works to emphasize the shape away from this visual hazard. An excellent design in which overhang effect has been eliminated is the Frigidaire range shown in ***Fig.*** **5.**

Machine Should Have "Professional" Look

Closely allied to the old-fashioned look is the "home-made" look. Few customers will be impressed with a product that looks as though it could have been produced in a home workshop. Therefore, it is often necessary to disguise some methods of manufacture. In days past one of the easy answers to this was to introduce a chrome strip applied over certain joints. This device has become outmoded and generally denotes a cheap product today. Such trim strips are visually unsatisfactory because they tend to cut up the form of the product. They should be confined to the department of afterthoughts and last resorts, particularly since they are generally ill-fitting. Wherever the customer can pry something loose with his fingernail, doubts arise in his mind about the quality of the product. A good example of forthright design, effected without resort to superficial trim is the Hallicrafters receiver shown in ***Fig.*** **6.**

Designers can increase ease of machine operation by grouping the controls, ***Fig.*** **7,** not only according to function but by tying them in with the visual pattern as well. Thus, they create a simple memory pattern which not only aids the operator of the device in performing his task but emphasizes the identity of the machine as positively as if the manufacturer had written his name across the front in foot-high letters. Sometimes it is necessary to complicate mechanisms in order to achieve this, and surprisingly often it is worth the effort.

Often it is cheaper and more effective to redesign the surroundings of a component than to tamper with mechanism. This brings in the treatment of escutcheons, decorative frames, etc. In the appliance field these usually are plated brass stampings. Formerly they were modest affairs with shallow flanges, not far removed from the cheapest form of etched plate of the sort used in indicating voltage and catalog numbers on the backs of appliances. When they were given any depth, they were generally of bulbous pattern to delight the heart of the press shop. They were obviously hollow and looked inexpensive. It is well to remember that the customer does not like to buy any device that appears to be full of air. He resents buying empty space. To him, obviously hollow decorative pieces are classed under his nontechnical term, "tin".

For a considerable time designers have carried on a campaign (exasperating to the die shop) for sharp-edged metal stampings which counterfeit solid billets of metal. In fact, many look like extrusions which appear to have been cut from a slab of virgin metal in which the customer feels a pride of possession. An additional reason for these crisp shapes in decorative pieces is that the soft contours generally given to the body of most appliances today can become monotonous in the extreme. Crispness is needed for contrast; otherwise the product can look like a slightly melted pat of butter.

Appropriateness of a machine's appearance can be assured in many ways by the designer. This problem has its analogy in whether or not to wear white tie and tails or merely a business suit when, in either case, all we are planning to do is dine. Champagne

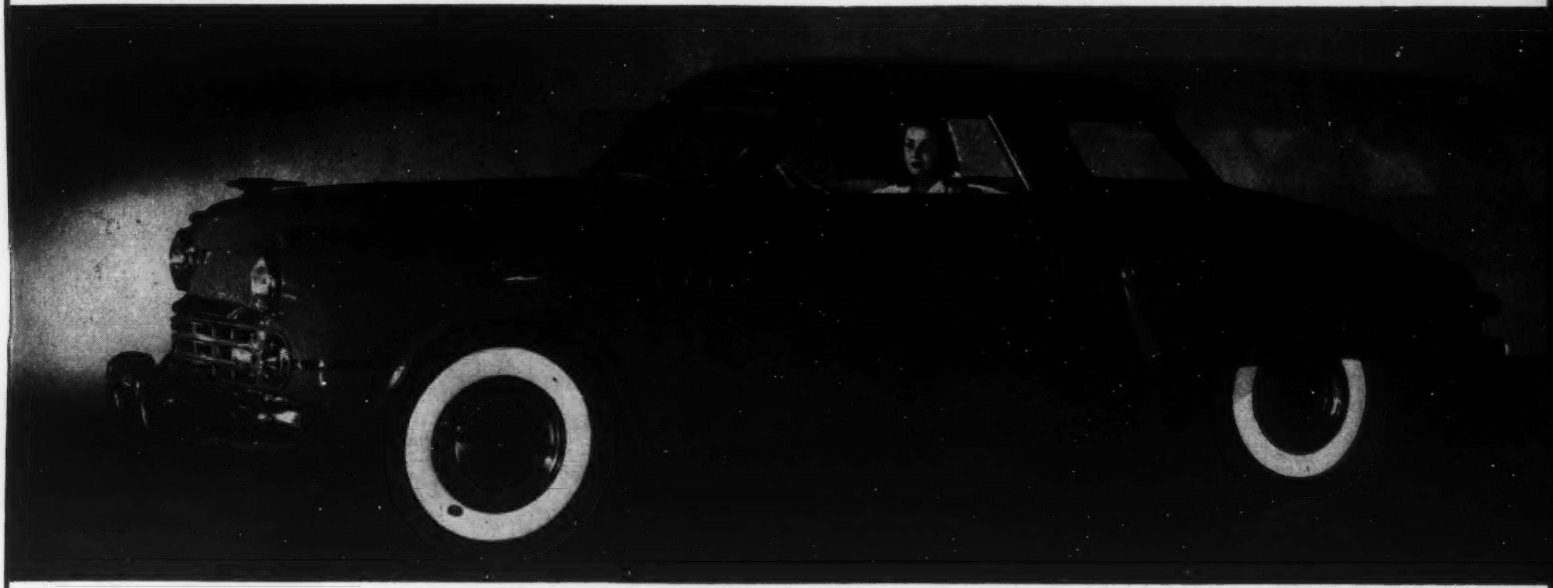


Fig. 8—Good example of the "anthropomorphic effect" is the headlight and grille arrangement of this Studebaker which, suggesting discreetly bared fangs, connotes great latent power and speed

or beer, the product must be in harmony with its surroundings. Thus, it is up to the designer to avoid anachronistic practices, such as using kitchen white for a living-room piece, ending up with a hospital effect fairly reeking of antiseptic.

The term "balance" often used by the aesthetic-minded simply means: "So it won't fall over." Consider a hypothetical forming-press with its attendant hydraulic pump. One might find that the two units, viewed together, give a visual impression of instability. Frankly, the press looks as though it were on the point of toppling over because of some bulky overhanging projections. The fact that everyone in the engineering department knows that the weight of the hydraulic unit is more than enough to keep the press from toppling will not relieve the onlooker of anxiety about impending disaster. Designwise, it is a simple problem to shift the emphasis on the overhanging bulk elsewhere so that the unfortunate press again seems to be firmly rooted and efficient.

When Machines Look Like Men

What is known as the "anthropomorphic effect" is encountered in design where inanimate objects assume human facial expressions. The facial expression of a motor car front end has killed many a design on the drafting board. Placement of the head lamps and grille is the root of the trouble. An element of restrained ferocity (the grille suggesting discreetly bared fangs) denotes latent power which, in turn, means speed in the automotive world (see *Fig.* 8). Similarly, a molding strip located too far down might suggest a pair of trousers that have slipped, which is certainly an unflattering condition. To cite another case, it is recognizable that poorly shaped fenders could appear to have baggy knees.

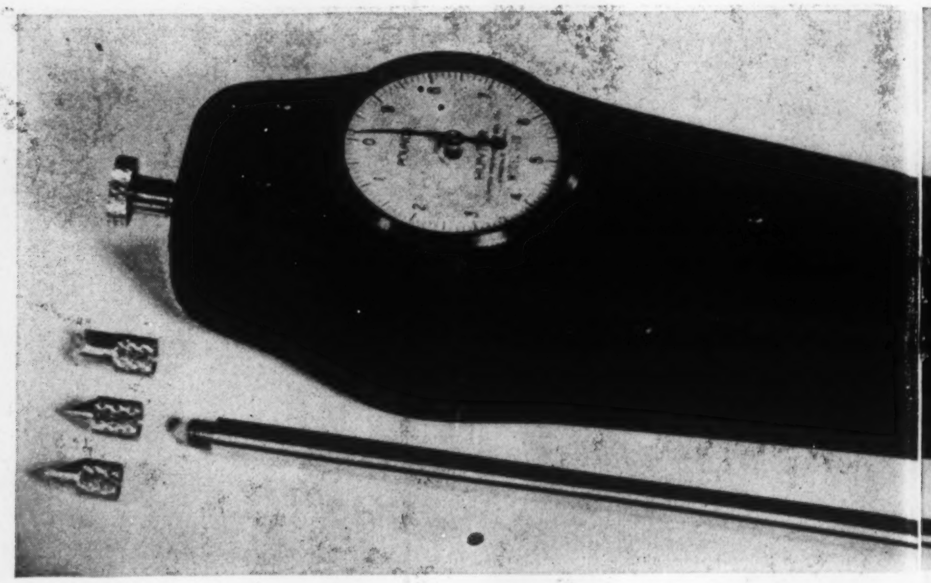
DESIGN FORMULAE: One hears much about "functional design" from various critics, most of whom imagine industrial design to be a phase of the art world. Functionalism as such is mainly the province of the engineer. For instance, an automobile is truly functional in its chassis and motor, but the body design is much more than functional. Aside from its obvious function of keeping out the wind and rain, the body's primary purpose is to help sell the car. Expensive trim and detail, both inside and out, are there for a very real purpose. They denote luxury and up-grade the car from mere basic transportation to the rank of a prize possession in the mind of the buyer.

Very often it must seem to the production engineer that the designer is asking for certain things intentionally to complicate production problems. However, when there is complete understanding of why certain things are requested, it will be apparent that the designer has not been motivated by ignorance nor by any desire to annoy the engineer. Unless this is understood, it may sometimes appear that the designer is being arbitrary.

It will be seen, when one traces the principles of industrial design to their sources, that there is no mystery except that which is brought into the picture by the careless use of such words as "aesthetics", "balance" and "proportion". Industrial design is motivated by the desire to appeal to the foibles of the consumer—the true and false notions and prejudices that exist whenever anything is bought or sold.

They Say...

"The salient characteristic of our age is not science or technology or atomic energy. On a world-wide basis it is politics and in many parts of the world, power politics"—ARTHUR VANDERBILT, *dean, School of Law, New York University.*



By A. L. Godshall
Designer, Apparatus Division
Hunter Spring Company
Lansdale, Pa.

Compensated Spring System in New

THERE are times when spring specification is based more upon guesswork, estimation or hope than upon any precise measurement of the forces which a spring should exert in service. To make possible spring specifications based on actual test needs, engineers of Hunter Spring Co. have developed a convenient, simple, portable instrument, *Fig.* 1, with which the designer can take force measurements right in the machine where the spring is to be used.

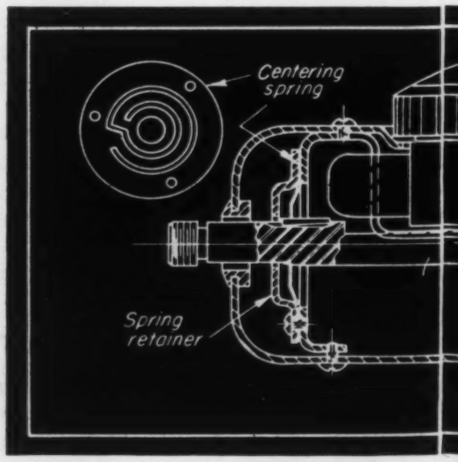
This new instrument, called the Force Indicator, is an interesting example of development in instrument design based upon precision compensated-spring systems.

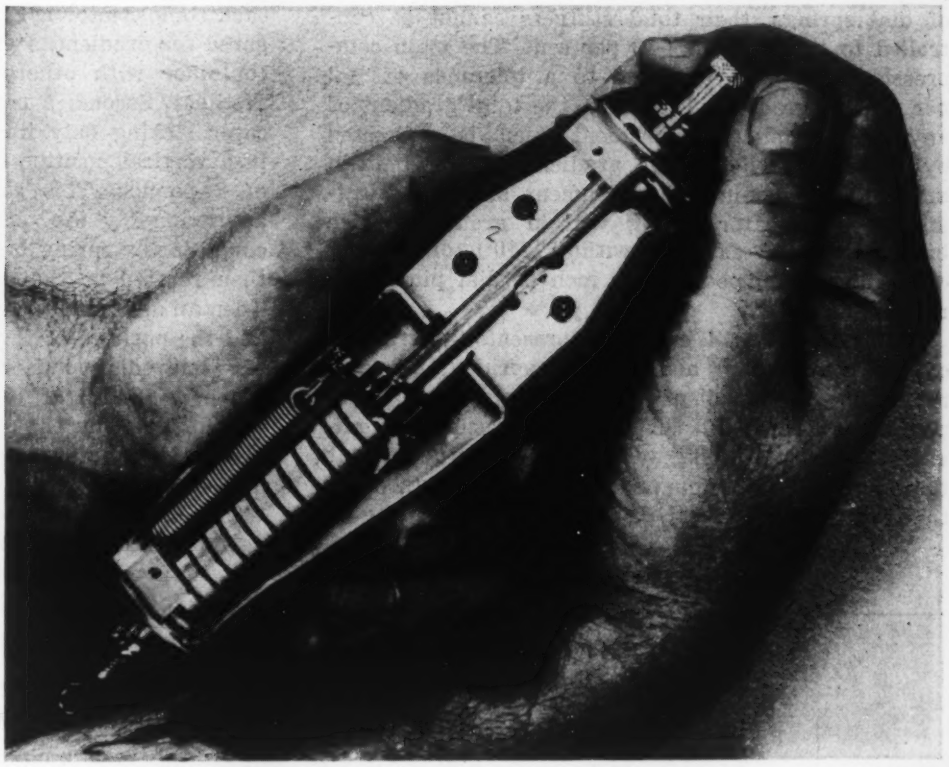
Essentially, it is a calibrated spring system linked to an indicating gage, *Figs.* 2 and 3, fitted with attachments for convenient application of pull or thrust loads upon various types and shapes of mechanisms which are to be spring-operated. It has an accuracy of ±1/10th of one per cent in overall spring gradient.

Referring to *Fig.* 3, the load, exerted through the free-floating transmission rod, is transmitted through the main spring collar to the free end of the main compression spring. The pin of the dial indicator bears upon the flange of the main spring collar and, therefore, exactly measures main spring deflection. The compensating spring is an extension spring which pre-loads the main spring so that the nonlinear characteristics of the load-length relationship for any compression spring near its fully expanded free length are avoided.

One of the major design refinements of the force indicator is the virtual elimination of friction in the force transmission system. There is no need for adjustments or corrections for friction. The force transmission rod is supported only by two centering springs punched from thin blue tempered spring steel (0.007-in.) and providing a 340-degree spiral between rim and center. Thus, there is no movement of metal against metal (either sliding or rolling) as in the case of bearings. The spiral springs (of the same type used to position the voice coils of loud speakers) simply center the main rod virtually without restraint (less than 0.06 pounds). To restrict lateral movement of the force transmission rod in the case of overloads, the centering spring retainers are cupped and drilled with a rod-clearance hole. The cupping is necessary to allow space for the centering spring action.

Damage due to over-capacity use is avoided through a limit-stop pin which rides in a slot in a lip on the heavy main frame. It is noteworthy that the centering springs at each end are quite stiff against rotation of the force transmission rod, even as they are extremely limber to its longitudinal translation. The reason, of course, is the 20:1 ratio of breadth to thickness. Thus, the limit stop pin is never permitted to ride on either side of its slot and introduce friction.





Instrument

Establishing The Exact Instrument Gradient: Even more important than friction elimination, however, is the compensation of the spring-system gradient, so that it is exactly 100 pounds per inch of dial pin movement with the extraordinary tolerance of ±1/5 of one per cent. Since none of the springs in the system is manufactured to tolerances closer than ±2 per cent in gradient, this accomplishment is quite interesting.

Here is how it is done. The spring system of the force indicator is a parallel network comprising the main spring, the compensator spring, the rod-centering springs, and the springs (two) internal to the dial indicator. The gradient of the total is the sum of the gradients of the components. For purposes of analysis, consider the components as three: (1) The light internal springs (the two centering springs and the two springs inside the dial indicator), (2) the main spring, and (3) the compensator spring. The internal springs account for approximately only 1.5 pounds per inch of the stiffness of the system. The main spring is designed for 89.6 pounds per inch of gradient while the compensator spring is designed for about 8.9 pounds per inch.

Due to thickness variation in the centering springs and inherent variation

Fig. 1 — Above, left — Force Indicator, which measures force required of a spring at point of application

Fig. 2—Above — Force Indicator with back cover removed showing force transmission rod, main compression spring, compensator spring, and spring collar which actuates dial indicator pin

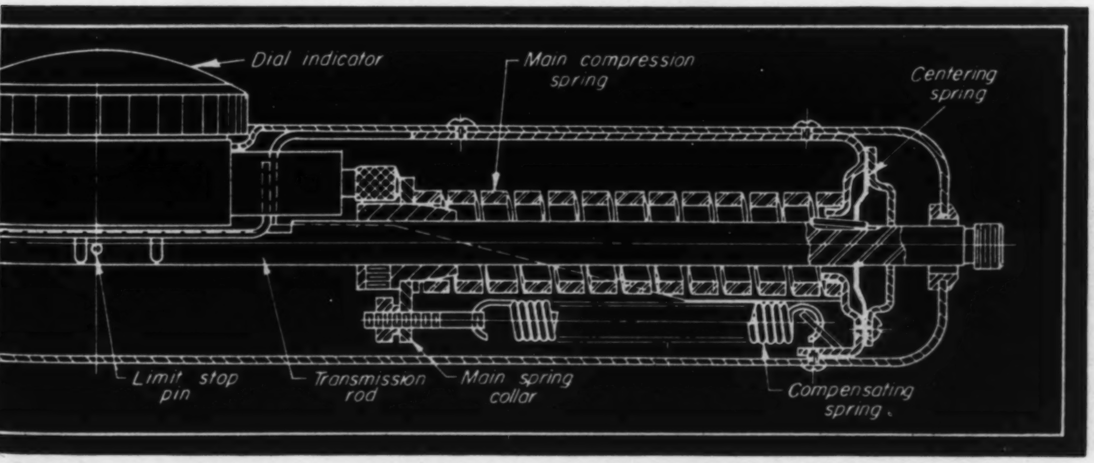


Fig. 3—Left—Cross section through Force Indicator shows arrangement of its primary components

of dial springs, their total stiffness cannot be controlled to better than ±10 per cent. The main compression spring is produced to a tolerance of ±2 per cent in gradient. Therefore, the total gradient of any one completed instrument must be corrected by measuring the actual gradient of the built-in and main springs in each instrument, and then selecting a compensator spring with a gradient which brings the total exactly (within 1/10th of one per cent) up to 100 pounds per inch of dial pin movement.

Referring to *Fig.* 4, curve *A* represents the gradient of the compression and interval springs; curve *B* represents the gradient of the extension or compensating spring; and curve *C* is the resultant gradient of the whole spring system. It will be noted that the extreme ends of curve *A* are nonlinear. In order to avoid this nonlinearity, the extension spring is made to exert a force of two pounds on the compression or main spring to bring the system into the linear part of the curve. Because the resultant gradient of the whole system (curve *C*) is the sum of the gradients of all the springs in the system, curve *C* is simply obtained by adding curves *A* and *B*. The gradient of curve *C* is made to equal 100 pounds per inch by choosing an extension spring whose gradient is 100 minus the sum of the gradient of compression, dial indicator and centering springs. In *Fig.* 4 the extension spring has a gradient of 10 pounds per inch (100—90).

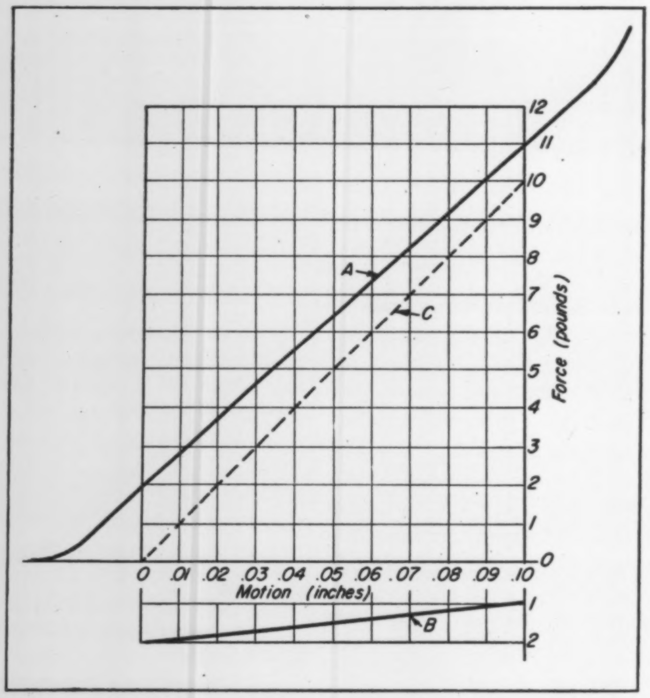


Fig. 4—Curve A, gradient of the compression and interval springs, has nonlinear extremities. Curve B is the gradient of the compensator spring which preloads the compression spring. Curve C, resultant gradient of the entire system, is the sum of curves A and B

Spring selection is accomplished as follows: First, each compensator spring in a production run is measured for gradient, segregated and placed in a labeled container with others exhibiting exactly the same gradient. Second, a completely assembled force indicator lacking only its compensator spring is set up in a vertical position and loaded with a dead weight of 2 pounds. This compresses the main spring to approximately the position it will occupy after the compensator spring is installed. The dial gage rim is then rotated so that a reading of zero is obtained. Then an additional dead weight of 10 pounds is added, and the position of the pointer read. The pointer will have moved beyond one complete revolution because of the stiffness of the compensator spring, and it will indicate, by the amount of this excessive movement, the exact gradient of compensator spring required.

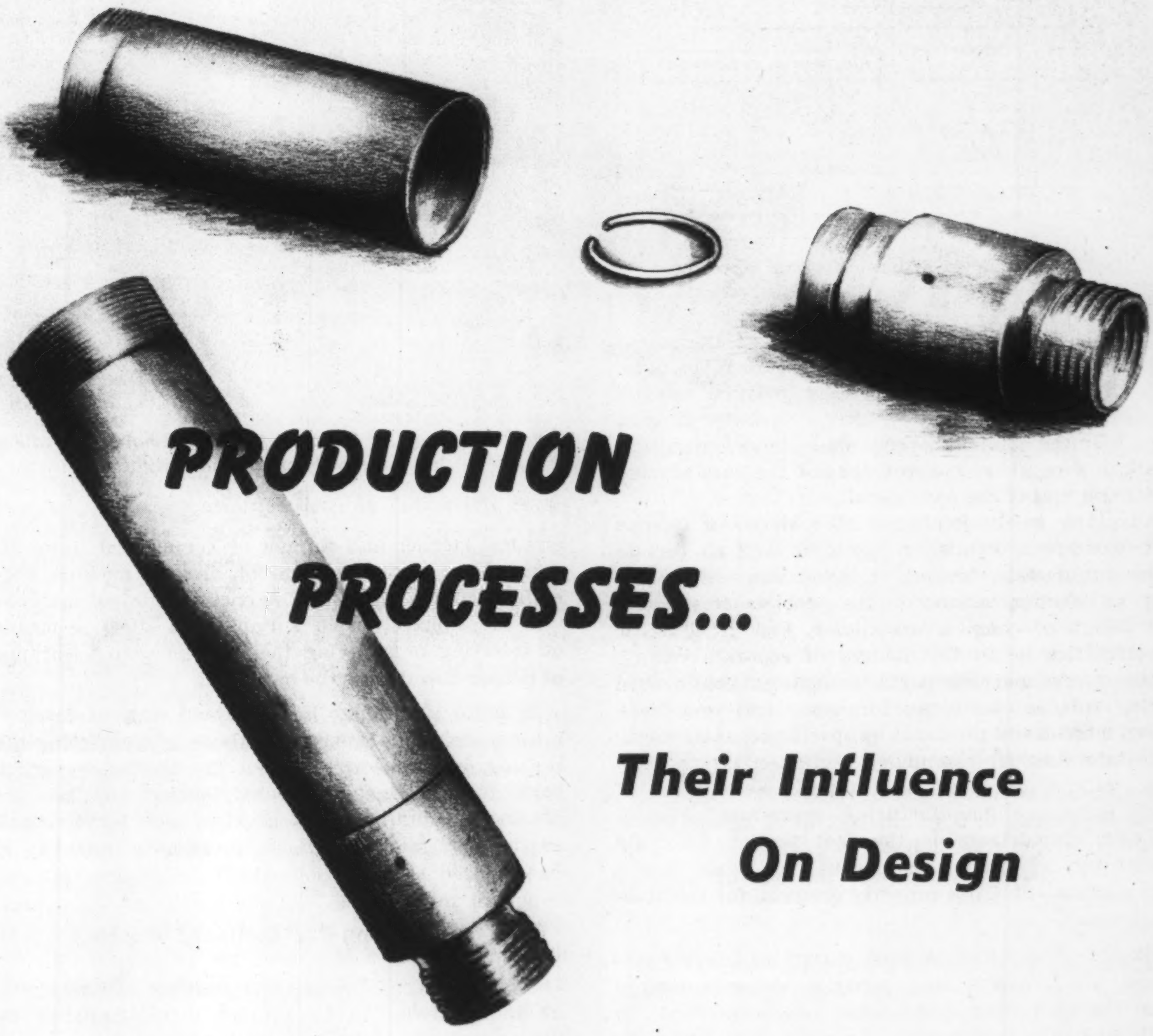
The only errors involved in this method of precision gradient-adjustment are the errors of the testing equipment and the precision with which the tested compensator springs are sorted in a production lot. Testing errors are extremely small. At Hunter, the compensator springs are graded within one per cent. Since the stiffness of the compensator spring is only 10 per cent that of the total system, the overall errors of the method are less than 1/10th of one per cent.

Dial Indicator Sets Overall Accuracy

In use, of course, the precision of the dial indicator is not greater than ½ of one per cent of full scale reading even though each fully jewelled instrument is submitted to thorough acceptance testing and premium prices are paid for closer tolerances than the dial gage industry generally offers to meet. Therefore, the overall compensated-spring system of the instrument is adjusted to a nicety well beyond the dial gage accuracy, and the quality of the dial gage becomes what is essentially the quality of the total device.

As will be seen in *Fig.* 2, the housing of the force indicator is shaped for easy one-handed operation. Six stainless steel force-transmission-rod fittings give the instrument a wide range of usefulness. These fittings include: A simple thrust button, a pulling hook, a conical-point force applicator, a V-notch thrust fitting for lateral rod pressures, a chisel fitting for re-entrant edges and notches, and a 6-inch rod extension. The instrument is made in ten-pound and one-pound capacities having the extremely close built-in accuracies of ±0.05 pounds and 0.005 pounds, respectively.

The method of sorted spring components herein described has already attracted the attention of one designer who wanted greater accuracy than had previously been possible with a single spring. Wherever the designer faces the need for load tolerances closer than are obtainable with normal spring-making practice, consideration of a compensated spring system (with sorted and matched components) following the design of the Hunter Force Indicator, may disclose dollar-saving and design-simplifying opportunities.



PRODUCTION PROCESSES...

Their Influence On Design

By Roger W. Bolz

Associate Editor, Machine Design

Part XLII–Production Brazing

THE manifold advantages of brazing, both designwise and economically, have been recognized for many years. Furnace brazing on a mass-production scale was first introduced commercially about 1930. Developments in the succeeding years have broadened the range of application and expanded the basic brazing alloys available to such an extent that today almost any metal or metals can be brazed by anyone of seven basic methods, *Fig.* 1.

Generally, the term brazing is applied to that group of welding processes in which metal components are joined together by means of a nonferrous metal or alloy brazing medium having a melting point over 800 F but less than that of the parent metals or alloys. In the heating operation the brazing medium melts, wetting the surfaces to be joined and creeping into and

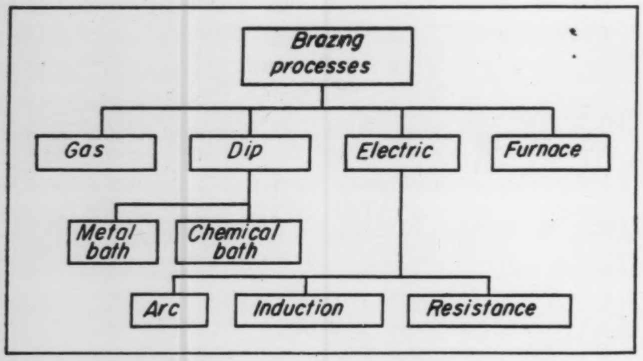


Fig. 1—Breakdown of basic brazing processes

Fig. 2—A group of furnace-brazed assemblies indicating the complexity of design possible

through each joint by capillary attraction. A limited amount of alloying with the parent metal takes place and any slight excess of brazing medium usually forms a neat fillet at the outer extremity of each joint. Brazed joints, properly made, have a resultant strength somewhere between that of the cast brazing metal and that of the base metal.

Adaptable to the joining of all varieties of ferrous and nonferrous metals or alloys as well as certain refractory metals, brazing in many cases offers the only satisfactory answer to the problem of economical design of complex assemblies, *Fig.* 2. Further opportunities lie in the joining of separate components—screw machine parts, stampings, cold-headed parts, tubular sections, forgings, and machined pieces most easily produced by specific separate methods—into finished assemblies not practical to complete without recourse to a formidable number of more expensive manufacturing operations, *Fig.* 3. Of equal importance is the fact that a decidedly higher rate of production per unit of labor invariably results with parts properly designed for the brazing process.

BRAZING MEDIUMS: A wide variety of brazing mediums are available and selection depends mainly upon the application and parent metals involved. In addition to the time-honored copper and brasses with which the brazing process started, mediums now include a wide selection of silver brazing (solders) alloys as well as those for alumnium and magnesium, the most recently developed. A general cross section of these brazing mediums is listed in TABLE I along with their major properties and characteristics.

Both silver and copper brazing are widely employed. In general, silver brazing is less expensive than copper brazing inasmuch as somewhat less work is involved, furnace temperatures need not be as high, and fits are less critical. Copper, of course, cannot be used on metals with low melting points. Conversely, most silver alloys are unsuitable for assemblies which require subsequent heat treatments at elevated temperatures.

Brazing mediums can be applied in several forms: (1) Wire in the form of rings or other shapes; (2) foil or thin strip of any form or shape for placement between sections to be joined; (3) punchings or slugs; (4) electroplated and sprayed metals or, as with aluminum, a metal coated with an appropriate medium or filler metal; and (5) pastes of copper powder, lacquer and thinner or commercial paste alloys. Most desirable form of brazing medium normally depends upon the particular design involved and the simplest, most suitable and effective means of inserting or applying the medium with assurance of proper flow during the operation.

BRAZING METHODS: In its present state of development some seven separate methods of completing the brazing operation are in use. The method by which parts to be brazed are heated to melt and flow the brazing medium depends greatly upon factors such as the particular design, its complexity, quantity to be produced, etc.

Gas Brazing for Localized Heating

Gas Brazing: Preferential heating of assemblies at the portions to be brazed is accomplished by means of torch or gas-radiant heating. Inasmuch as a protective atmosphere is generally required in brazing steels, gas brazing is normally relegated to use with the lower melting silver brazing alloys. Avoidance of heating entire assemblies with subsequent substantial cost savings is often important, *Fig.* 4. In the brazing of small assemblies, gas torches—oxyacetylene, oxyhydrogen, oxy-commercial or commercial gas—either hand operated or machine mounted can be used to advantage.

Dip Brazing: Brazing of parts by dipping is carried out by either of two methods. In metal-bath brazing, the fluxed parts are immersed in a molten bath of brazing medium. Parts are suspended in the bath to the required depth and held until they attain bath temperature, after which immersion in a cleaning solution removes the flux. Only relatively small parts are handled in this manner for obvious reasons. Chemical-bath or salt-bath brazing is adapted to larger parts and consists of immersing the parts to be brazed in a molten salt solution, *Fig.* 5. Salt-bath brazing has the advantage of heating parts rapidly and simultaneously, providing complete pro-

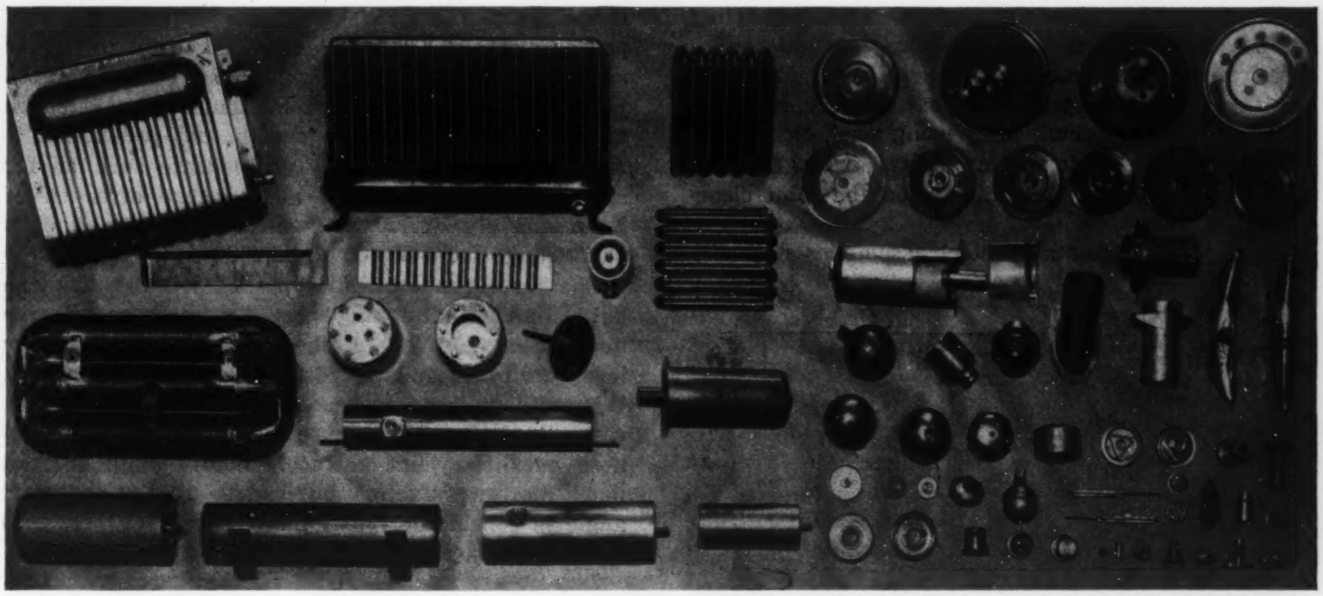


Fig. 3—A group of typical furnace-brazed parts produced in large quantities

tection against decarburization. In fact, parts made of suitable alloy may be silver brazed and carburized simultaneously, although the case is usually only 0.001 to 0.005-inch thick. Copper brazing in salt baths is especially advantageous with medium-carbon, alloy and high-carbon steels inasmuch as the decarburization sometimes encountered with atmosphere furnaces is not present, *Fig.* 6.

Electric Brazing: Three methods of electric brazing utilized are: Arc, induction and resistance. Arc brazing consists of heating the joint by means of an electric arc formed between the base metal and an electrode or between two electrodes. The carbon arc is the most common method but arc brazing in general is little used. Induction brazing offers an advantage in that only shallow annealing of the parts is produced with little oxidation and distortion. Preferential heating of only the local braze area, as with gas brazing, reduces the heating requirements and makes possible rapid joining of complex assemblies, *Fig.* 7. However, special heating coils are normally required for each job, *Fig.* 8.

Resistance Brazing

In resistance brazing, the third of the electric methods, heat is generated by passing an electric current through the parts to be brazed. Regular resistance welding machines can be used or the current can be applied through a set of carbon blocks, *Fig.* 9. Resistance welders offer accurate timing and very high-speed brazing on small assemblies. With either resistance method, heating is performed under pressure maintained until the metal solidifies; clean, neat joints are obtained with little heat effect on the parts.

Furnace Brazing: Both electric and gas fired brazing furnaces in box, wire-mesh belt and roller hearth types are used, *Fig.* 10. The primary advantages of furnace brazing are low costs, flexibility allowing the brazing of light and heavy sections, extremely high production speed, capacity to handle any brazing medium, no need for fluxing except with brass (or other alloys containing zinc) and aluminum, and no limit to the number of joints which can be brazed simultaneously. Perhaps most important is the factor of multiple-joint brazing; all joints on an assembly can be completed at once regardless of their inaccessibility, nonsymmetrical shape, depth, or number. Heat treatments such as normalizing, carburizing or hardening of ferrous materials can be made by proper control of the brazing cycle and furnace atmosphere.

DESIGN: The first consideration in the design of brazed parts is that of the type of joint to be specified. Some factors of joint design depend upon the brazing medium to be utilized. Copper brazing de-

Fig. 4—Gas flame brazing is utilized with large parts, such as this electronic power tube, where some degree of heat localization is desirable for this operation

mands extremely close fits and silver alloy brazing allows slight clearances but in no case does high strength emanate from filling large spaces or from filleting. The strongest, most satisfactory and economical joints are obtained by using small clearances. Shear strength of joints in general averages from 25,000 to 40,000 psi depending upon the joint clearance.

Copper-brazed joints in steel assemblies normally range from 27,000 to 33,000 psi in strength with proper clearances whereas this may drop to as low as 22,000 with a considerable gap. Silver-brazed joints will often test with a minimum shear strength of 35,000 psi and where design and production is rigidly controlled, primary components such as for aircraft actually show a mean shear strength of approximately 43,000 psi. Overall values on such parts range from 38,000 to 52,000 psi.

Fig. 5—Removing a fixture of copper-brazed parts from a salt-bath furnace

The three fundamental types of joints which can be utilized in designing brazed assemblies are the butt, scarf, and lap or shear. Butt joints are the least desirable and, if possible, should be avoided. Where there is no alternative, butt joints should be carefully designed to assure a close fit and good flatness over the joint surface. Scarf joints are not much more satisfactory but can be used if the scarf angle is considerably less than 90 degrees. Stepped scarfs are also acceptable.

Lap joints are the most useful and satisfactory and are the only acceptable joint for primary components. The lap can be made whatever length is necessary to maintain adequate strength and factor of safety. In general, laps in copper, brass and other nonferrous alloys with a depth approximately three times the gage will produce a joint as strong or stronger than the parent metal. With metals of different gage the lap depth is generally based on the thinner piece. Where dissimilar metals or critical parts are to be joined it may be desirable to compute the required amount of overlap as follows by

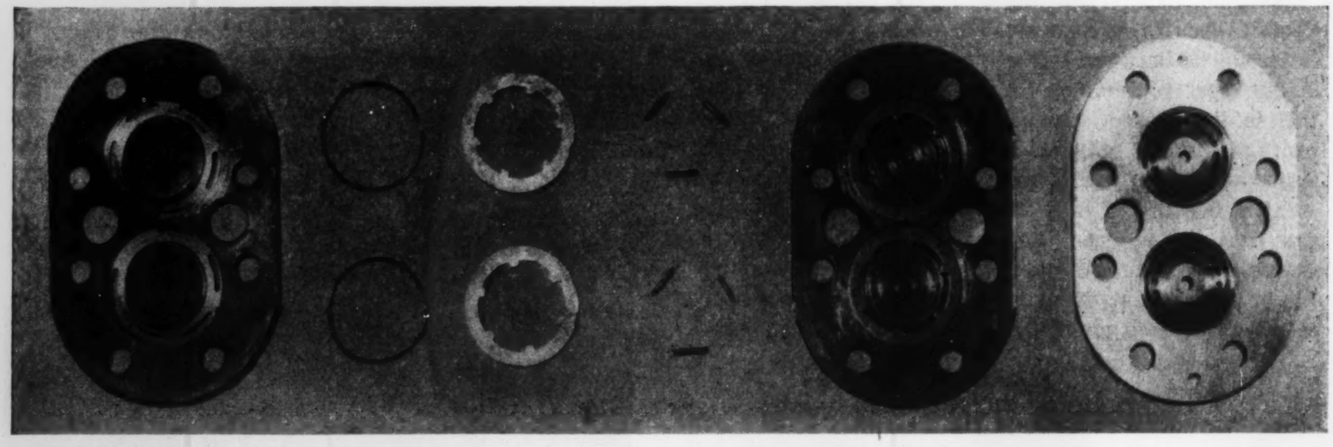


Fig. 6—Above — Compressor valve plates and component parts, including brazing wires, salt-bath copper brazed to avoid decarburization of the material

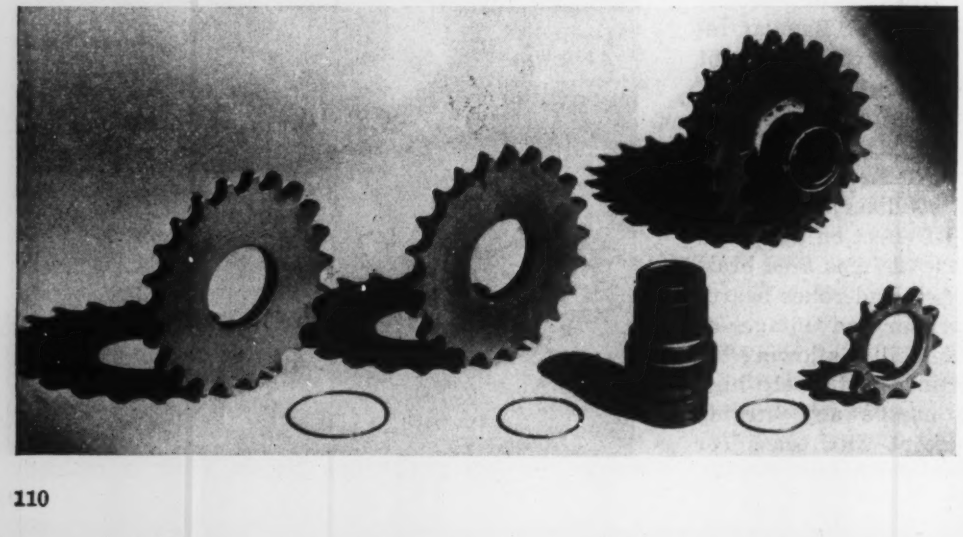


Fig. 7 — Left — Farm machine sprocket assembly designed for induction brazing with silver alloy

equating the strengths on a total or unit length basis:

$$SB = Bl\frac{25{,}000}{f} \text{ or } l = \frac{Sf}{25{,}000}$$

where S = the strength of the weakest member (tensile strength × thickness) in psi; l = the depth of lap in inches; B = the circumference, length, or unit length of the lap in inches; and f = the factor of safety. A unit shear strength of 25,000 psi is normally used for brazing alloys and the factor of safety may range from 2 to 5. For low stresses and static loadings, a value of 2 is satisfactory but for primary structures involving dynamic stresses, a higher value should be specified to suit the conditions. Either flat or tubular lap joints may be calculated with the preceding formula and the load must be equally distributed over the entire braze area.

Typical lap type joints generally utilized in brazing design are shown in *Fig.* 11. For maximum economy in production, joint depth or overlap should be no greater than necessary. Generally, it should not be required that the brazing metal from one preplaced

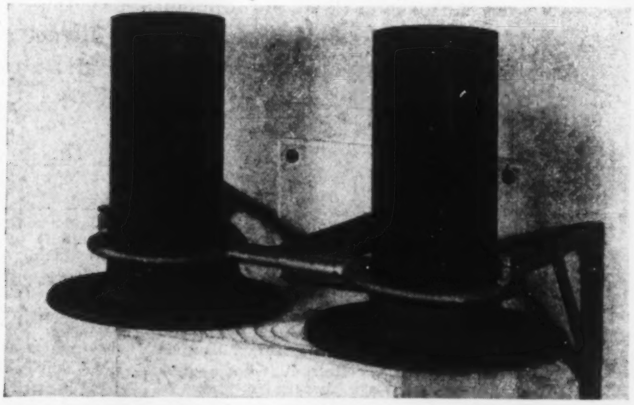
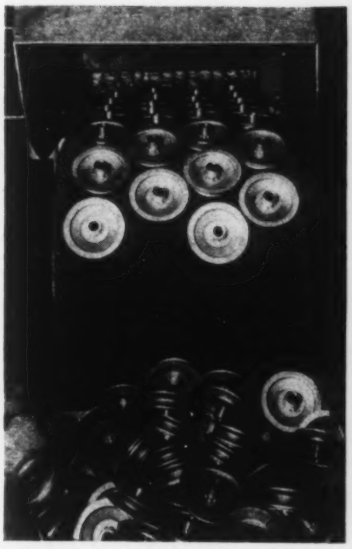


Fig. 8—Above—Induction brazing equipment showing parts in place and finished assembly

Fig. 9—Below—Resistance brazing the connections to the bars of a large armature assembly

Fig. 10 — Discharge end of a wire-mesh belt furnace in production brazing of automobile generator pulleys



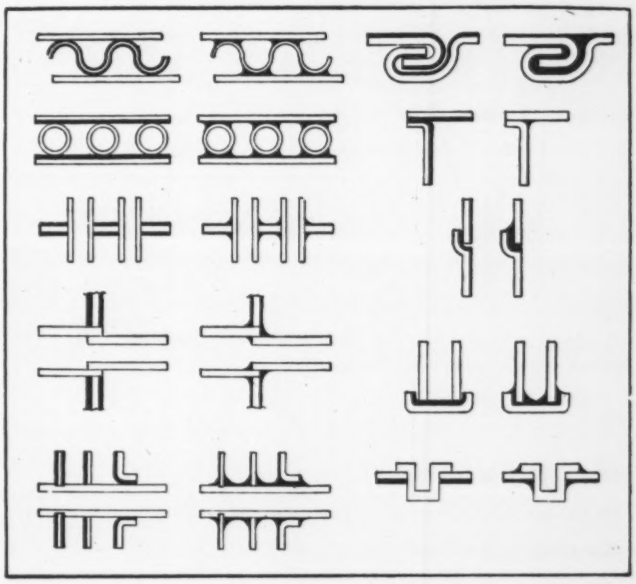
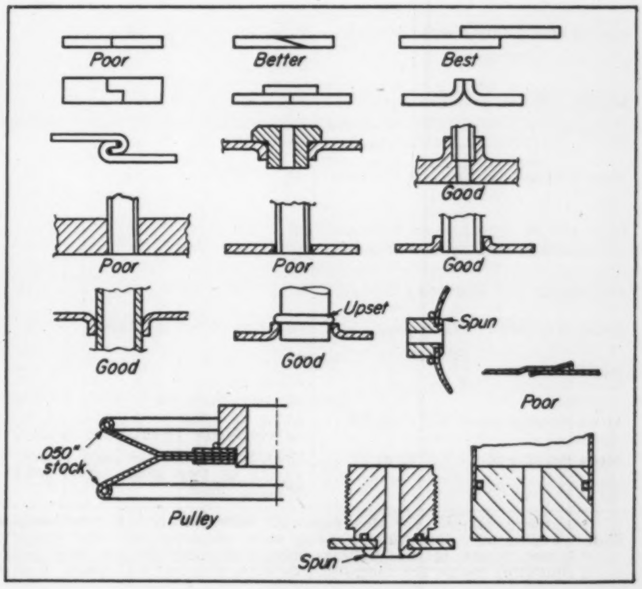


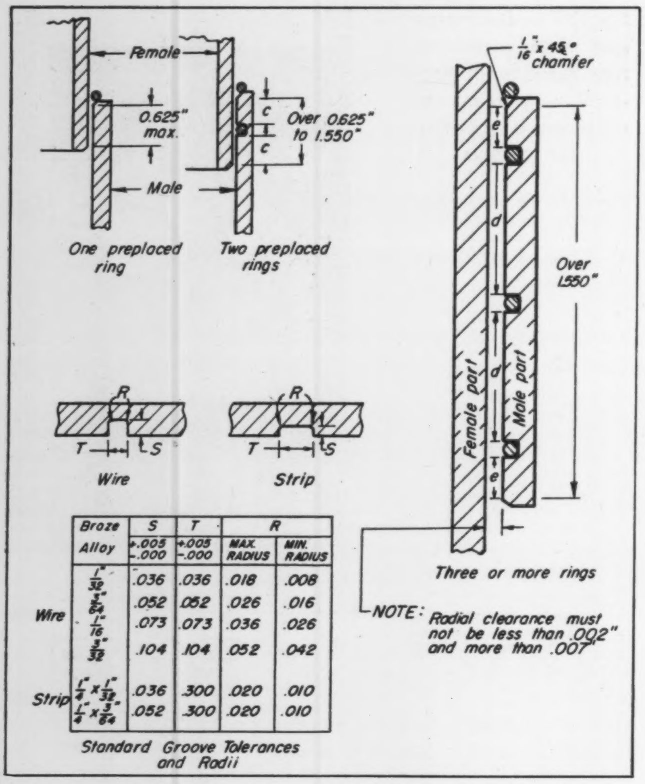
Fig. 11—Typical lap joints utilized in designing brazed assemblies, below. Typical joints with aluminum brazing sheet, before and after brazing, are shown above



ring penetrate or creep between more than ⅝-inch of overlap where silver-brazed steels are involved. Copper brazing of steel is not as restricted; copper at furnace temperatures of 2000 to 2100 F is highly fluid and penetrates more deeply. Combinations with high melting point silver alloys as well as copper which are mutually soluble to a high degree—for instance, copper on nickel or silver alloy on copper—usually are restricted to depths of penetration under ¼-inch.

Where design requires long overlaps, it is well to provide a number of reservoirs of brazing metal to assure sound joints. Design criteria adopted for critical primary aircraft structures are shown in *Fig.* 12.

The lap depth plus the average clearance in the joint provides the data necessary to calculate the amount of brazing metal required. Because the strength of brazed assemblies is directly affected by the joint clearance, particular attention must be paid this detail. Copper gives the highest strength joints when the fit is from zero to minus 0.002-inch (interference) and maximum penetration also results within these limits. The practical limits generally followed in design of copper-brazed steel parts is to use a maximum press fit of approximately 0.001-inch per inch on diameter and for the opposite extreme, a maximum gap of 0.0005-inch per inch of diameter. The preferable joint clearance for silver alloys is



	Braze Alloy	S	T	R	
		+.005 -.000	+.005 -.000	MAX. RADIUS	MIN. RADIUS
Wire	1/32"	.036	.036	.018	.008
	3/64"	.052	.052	.026	.016
	1/16"	.073	.073	.036	.026
	3/32"	.104	.104	.052	.042
Strip	1/4" x 1/32"	.036	.300	.020	.010
	1/4" x 3/64"	.052	.300	.020	.010

Fig. 12—Lap joint design for primary structures

TABLE I—Commercial Brazing Alloys

Alloy	Composition								Temperature Range† (F)	Remarks
	Cu	Ag	Zn	Cd	Mn	Sn	P	Ni		
Copper	99+	..	..	..	..	..	..	..	1981	No flux required ordinarily. Steels having alloying elements of manganese, silicon, vanadium and aluminum in excess of 2% total require fluxing.
Brass	60	..	40	..	..	..	..	..	1600–1750	Requires flux. Used for brazing steel assemblies. Average strength equal to that of copper. For joining cast iron to steel. For torch brazing iron.
SN 7 (Handy and Harman)	85	7	..	..	..	8	..	..	1735–1805	For use where high temperature, low silver contact is wanted for subsequent heat treatment.
RT-Sn (Handy and Harman)	30	60	..	..	..	10	..	..	1095–1325	Used on electronic equipment where zinc and cadmium are undesirable.
Phos-Copper (Westinghouse)	93	..	..	..	..	..	7	..	1304–1382	For copper, brass or bronze. No flux necessary with copper. Cannot be used with steels.
BT* (Handy and Harman)	28	72	..	..	..	..	..	..	1435	Silver-copper eutectic.
ETX (Handy and Harman)	34	50	16	..	..	..	..	..	1275–1425	A general-purpose alloy for joining ferrous, nonferrous and dissimilar metals or alloys. Ductile, has high strength and good corrosion resistance.
Sil-Fos (Handy and Harman) ...	80	15	..	..	..	..	5	..	1185–1300	For copper, brass, bronze and other nonferrous materials only. Not suitable for ferrous materials.
Easy-Flo* (Handy and Harman).	15.5	50	16.5	18	..	..	..	..	1160–1175	Lowest melting point alloy for high-strength joints. For all ferrous and nonferrous materials and dissimilar metals. For cast iron.
Easy-Flo 3 (Handy and Harman).	15.5	50	15.5	16	..	..	..	3	1195–1270	Used for building up ferrous and nonferrous materials, bridging and filleting. Also for low-temperature applications on Stellites, carbides, tungsten and refractory alloys. Good corrosion resistance.
Re-Mn (Handy and Harman)	28	65	..	..	5	..	..	2	1385–1445	For high-temperature applications on Stellites, carbides, tungsten, and refractory alloys.
85-15 (Handy and Harman)	..	85	..	..	15	..	..	..	1750–1765	For applications involving materials with high strength at elevated temperatures.
Easy-Flo 45* (Handy and Harman)	15	45	16	24	..	..	..	..	1125–1145	Lowest melting point alloy. Similar to original Easy-Flo. For ferrous, nonferrous or dissimilar metals.
Easy-Flo 35 (Handy and Harman)	26	35	21	18	..	..	..	..	1125–1295	Used for building up, bridging and filleting.
TE Special* (Handy and Harman)	58	5	37	..	..	..	..	..	1575–1600	For use on steel where subsequent heat treatment is necessary.
SS (Handy and Harman)	30	40	28	..	..	..	..	2	1240–1435	For low-temperature applications on Stellites, carbides, tungsten, and refractory alloys.
Alcoa No. 716	(Brazing filler medium)								970–1085	For brazing 2S, 3S, 4S, 52S, 53S, 61S or 63S alloys. In wire or shim form. 53S and 61S are brazed at 1060 to 1090 F.
Alcoa Brazing Sheet No. 1 or 2.....	Alcoa 3S alloy core coated on one side (#1) or two sides (#2) with brazing filler								1160–1185‡	General-purpose alloy sheet for forming into parts. When light color or Alumilite finish is desired.
Alcoa Brazing Sheet No. 11 or 12...	Alcoa 3S alloy core coated on one side (#11) or two sides (#12) with brazing filler								1110–1140‡	General-purpose alloy sheet for forming into parts. Less distortion than Nos. 1 and 2.
Alcoa Brazing Sheet No. 21 or 22...	Heat treatable alloy core coated on one side (#21) or two sides (#22) with coating of brazing filler								1110–1120‡	Same heat treating practices as for 61S. Can be quenched direct from brazing furnace. General-purpose, high strength.

* Eutectic Alloys. For slow heating. Melt quickly and completely within a narrow temperature range and entire quantity of alloy flows at once. Wide temperature range alloys have more sluggish flow and should be used where fit is poor or where bridging or filleting is desired.

† Lower figure is the melting point and upper is the flow point at which all of the alloy is molten.

‡ Operating range for temperatures when brazing with these materials.

somewhat larger and can range from 0.002 to 0.007-inch. The preferable clearance being approximately 0.001 to 0.003-inch. Phos-copper alloy allows a fit clearance up to 0.003-inch but the strength of such joints is relatively low. With aluminum, press fits must be avoided. Clearances of 0.006 to 0.010-inch are suitable for lap joints under ¼-inch in length; proportionally greater clearances up to 0.025-inch are required for laps of greater length.

These general fits for parts are predicated upon the assumption that the metals involved have approximately equal coefficients of thermal expansion and that the parts are uniformly heated at a fairly low rate. Consequently, where conditions are otherwise it will be necessary to modify the actual part tolerances to assure a fit which will fall within the foregoing maximum ranges. For instance, in the design of such parts as tanks, differenital in expansion may dictate the most desirable type of joint. Solid steel disk types, *Fig.* 13, will not braze properly and the dished or inverted type head which can be pressed into place with adequate flange contact provides the best solution. Such heads remain in proper contact during the operation.

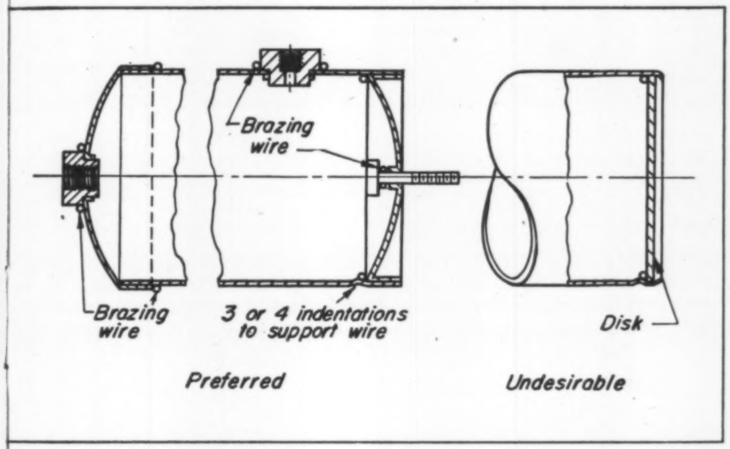


Fig. 13 — Above — End head design for cylindrical parts with area lap is preferable

Wherever joints are to be brazed in a vertical position it is well to provide a small chamfer on the edge adjacent to the braze or faying surface. A chamfer in the horizontal position, however, will often obviate capillarity. Finish on all surfaces to be used for brazing should be of a roughness value not over 100 microinches, rms. Surfaces such as those produced by cold drawing, stamping, deep drawing, or ironing can be utilized direct without further preparation besides proper cleaning.

Where close tolerances are desired after brazing, either extremely small clearances must be utilized to provide retention of the components during the brazing operation or fixtures for alignment and location of components must be employed. With the exception of dip brazing or salt-bath brazing, adequate consideration of the flow of brazing metal must be given. Joints should be designed to avoid flowing the molten metal against gravity. Generally speaking, the brazing medium should not be located between the parts to be joined except in a few cases where the parts are free to move together by gravity or be squeezed into close proximity by weighting. It is most practical to apply it adjacent to the joint and in contact with both parts. Where the medium in wire, slug, foil or other form cannot be held or applied conveniently it can be preassembled by means of grooves prepared for the purpose, *Fig.* 12.

Complex Fixtures Should Be Avoided

Brazed assemblies should be designed to allow the use of very simple support fixtures. Jigs or fixtures to clamp or hold assembled parts together should be avoided wherever possible because of high maintenance, etc. The press fits possible with copper brazing offer the most economical alternate to fixtures;

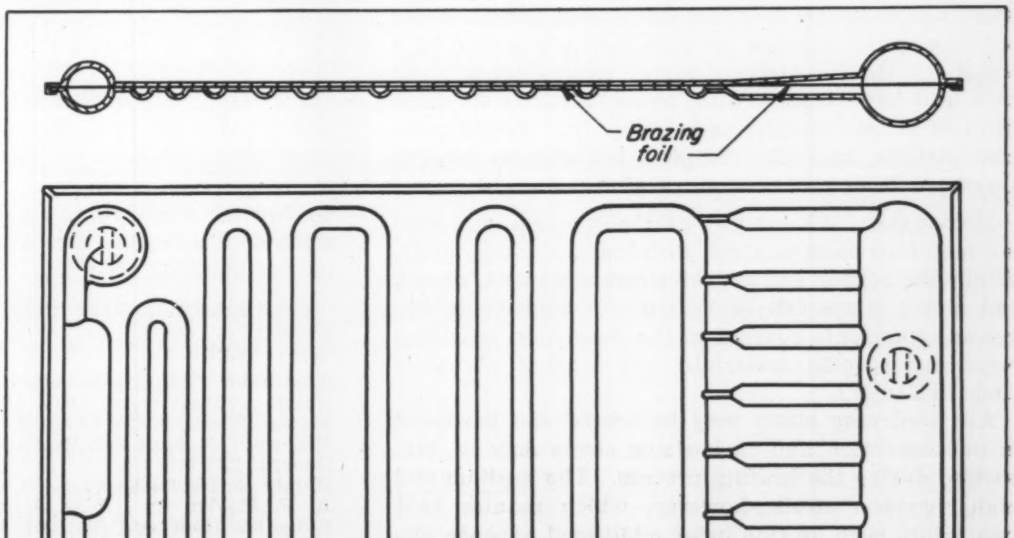


Fig. 14 — Right — Steel evaporator is assembled with foil and all four edges are folded over to retain alignment. Unit is brazed in the flat and later formed into the conventional U-shape

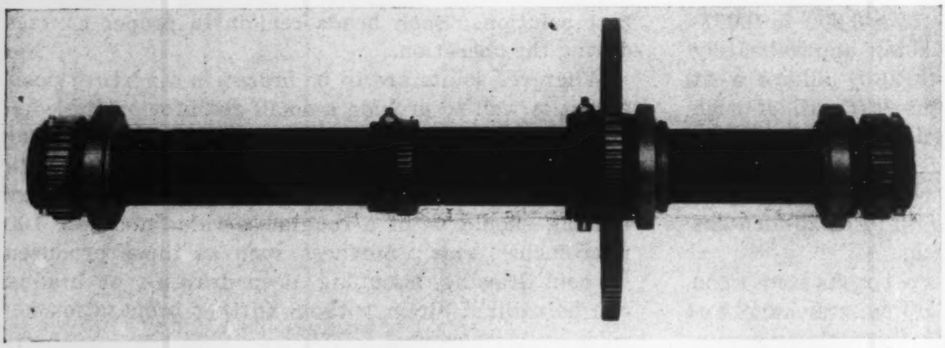


Fig. 15—Left—Hollow aircraft turret torque tube has heavy ends and gear-mount silver brazed in a salt bath. The finished part withstands a 2000 inch-pound torque test

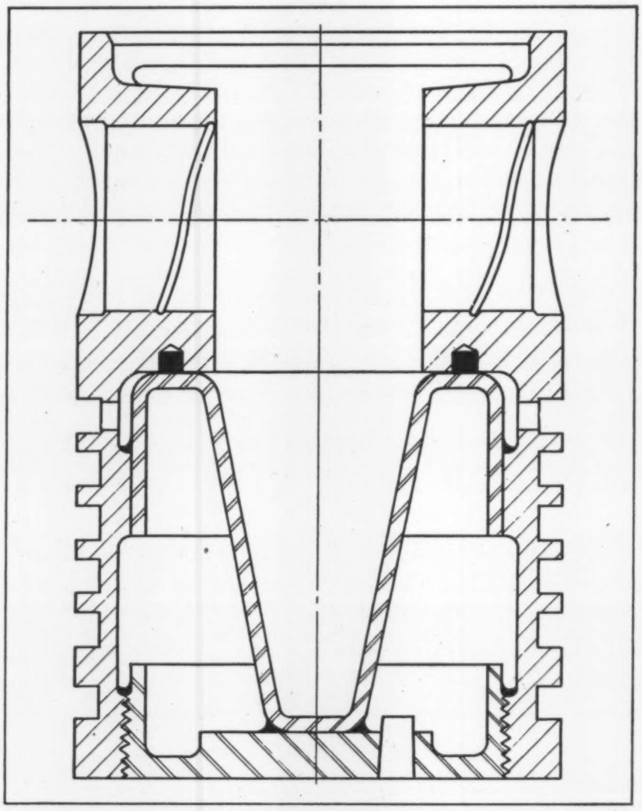


Fig. 16—Cast iron sodium-cooled piston is silver brazed at points a, b, c, and d to an iron head and steel container

fixtures are seldom necessary inasmuch as plain press fits, light scratch knurl press fits, and similar designs can be incorporated into a design to provide whatever location or alignment is necessary. Fixtures are not always practical with brazed aluminum work and consequently various methods of retaining are employed.

Lock seaming, crimping, flaring, staking, spinning and like fastening methods can be utilized to obviate fixtures. Aluminum parts, for instance have been stamped with tabs which were stapled together for the brazing operation and later sheared off. The evaporater trap in *Fig.* 14 is interesting in that a vacuum is used to promote close contact between the two parts as the foil melts. Tanks ordinarily should be vented and likewise any parts fitted into blind holes or recesses require some venting to avoid blowing apart during heating.

Thickness Variations

Generally, it is wise not to design parts for furnace brazing which have a wide range of thicknesses or great differences in mass. Too great a difference is reflected in unequal heating during the operation. Parts of aluminum may range from 0.006-inch to a maximum of ½-inch in thickness and occasionally this maximum can be increased. With due consideration of the extra heat consumed with heavier components, some designs nevertheless are completely justified. Hollow aircraft turret torque tubes have been salt-bath brazed with heavy sections at each end and at intermediate points, *Fig.* 15. Brazed cast-iron pistons, specially designed for sodium cooling also have been produced successfully, *Fig.* 16.

MATERIALS: Almost any of the common engineering materials such as steel, stainless steel, alloy steel, aluminum, copper and copper alloys, cast iron, nickel, and nickel alloys can be brazed. In addition to the general comments covered in the foregoing, reference regarding specific materials and brazing alloys is made in TABLE I.

Air hardening steels may be brazed and hardened in one operation and carburizing steels may be carburized during the brazing process. The medium and higher carbon steels, however, which require heat treatments such as this incur additional expense owing to closer control and increased handling.

TOLERANCES: Final assembled tolerances on brazed assemblies are dependent primarily upon the methods utilized in producing the various components. Where parts are finish machined after brazing, the desired tolerances can be held as required. However, where assemblies are to be completed by brazing and no further finishing is to be done, attention to the method of assembly for brazing will insure satisfactory commercial accuracy.

Collaboration of the following organizations in the preparation of this article is acknowledged with much appreciation:

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Improving Analysis of Graphical Records

By James Martin and J. H. Meier
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ENGINEERS frequently analyze data from strain gage and timing records, and are confronted with the problems discussed in the article "Analyzing Graphical Records" by C. E. Balleisen which appeared in MACHINE DESIGN for June 1948. Professor Belleisen's remarks regarding graphical differentiation are very much to the point, and in many cases the present authors also prefer numerical methods. However, they cannot support him unequivocally in his praise for the exclusive merits of numerical differentiation. While excellent methods of numerical differentiation can be, and for many problems have been, worked out, they are all afflicted with one great disadvantage: Slight inaccuracies in converting a chart into numerical values have a substantial influence upon the derivatives. Even with the best methods of numerical differentiation, the final results are generally no better than the results of graphical analysis carried out with reasonable care. It must be realized that successive derivation of test records is not, and never will be, an easy task when considerable accuracy is required. If numerical methods are to be used, the formulas ought to be selected with great care.

This article reviews the application of Newton's formulas,[1] which Prof. Balleisen discussed in his article, and points out their limitations for general cases. The more appropriate Bessel's formulas are proposed as an alternative, their superiority being demonstrated by comparison with the results of applying Newton's formulas.

> *ALTHOUGH INITIATED as a brief discussion and criticism of a recent article in MACHINE DESIGN, the material here presented assumed such major proportions as to justify its publication as a feature article on its own merits. It presents practical formulas for the calculation of derivatives of curves for which mathematical functions are unknown*

SUMMARY OF NEWTON'S METHOD: From any recorded curve, a series of rectangular co-ordinate values may be determined as follows:

Abscissa: $x_1, x_2, x_3, \ldots\ldots\ldots\ldots x_{n-1}, x_n,$
Ordinate: $y_1, y_2, y_3, \ldots\ldots\ldots\ldots y_{n-1}, y_n,$

where $x_n - x_{n-1} = \ldots\ldots\ldots = x_3 - x_2 = x_2 - x_1 = h =$ constant. Successive differences are computed as:

$$a_1 = y_2 - y_1,\ a_2 = y_3 - y_2,\ \ldots\ldots\ldots\ a_{n-1} = y_n - y_{n-1},$$
$$b_1 = a_2 - a_1,\ b_2 = a_3 - a_2,\ \ldots\ldots\ldots\ b_{n-1} = a_n - a_{n-1},$$

TABLE I

Successive Differences for Curve in Fig. 1

X (sec)	Y (in.)	a	b	c	d
0.00	4.34				
		.03			
0.01	4.37		.01		
		.04		.00	
0.02	4.41		.01		.00
		.05		.00	
0.03	4.46		.01		−.06
		.06		−.06	
0.04	4.52		−.05		.11
		.01		.05	
0.05	4.53		.00		−.05
		.01		.00	
0.06	4.54		.00		−.01
		.01		−.01	
0.07	4.55		−.01		.02
		.00		.01	
0.08	4.55		.00		.04
		.00		.05	
0.09	4.55		.05		−.05
		.05		.00	
0.10	4.60		.05		.07
		.10		.07	
0.11	4.70		.12		−.08
		.22		−.01	
0.12	4.92		.11		−.18
		.33		−.19	
0.13	5.25		−.08		(−.35)
		.25		(−.54)	
0.14	5.50		(−.62)		(1.49)
		(−.37)		(.95)	
0.15	5.13		(.33)		(−1.27)
		−.04		(−.32)	
0.16	5.09		.01		(.32)
		−.03		.00	
0.17	5.06		.01		.00
		−.02		.00	
0.18	5.04		.01		−.01
		−.01		−.01	
0.19	5.03		.00		
		−.01			
0.20	5.02				

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[1] References are tabulated at end of article.

etc., as far as desired. These values may be tabulated as in TABLE I, which is taken from Prof. Balleisen's article.

The formulas for the derivatives at the point (x_n, y_n) are:

$$\left(\frac{dy}{dx}\right)_n = \frac{1}{h}\left(a_n - \frac{b_n}{2} + \frac{c_n}{3} - \frac{d_n}{4} + \ldots\ldots\right) \quad (1)$$

$$\left(\frac{d^2y}{dx^2}\right)_n = \frac{1}{h^2}\left(b_n - c_n + \frac{11d_n}{12} + \ldots\ldots\ldots\right) \quad (2)$$

$$\left(\frac{dy}{dx}\right)_n = \frac{1}{h}\left(a_{n-1} + \frac{b_{n-2}}{2} + \frac{c_{n-3}}{3} + \frac{d_{n-4}}{4} + \ldots\right) \quad (3)$$

$$\left(\frac{d^2y}{dx^2}\right)_n = \frac{1}{h^2}\left(b_{n-2} + c_{n-3} + \frac{11d_{n-4}}{12} + \ldots\ldots\ldots\right) \quad (4)$$

Equations 1 and 2 are based on points (x_n, y_n); (x_{n+1}, y_{n+1}); (x_{n+2}, y_{n+2}); ...... etc., while Equations 3 and 4 are based on points (x_n, y_n); (x_{n-1}, y_{n-1}); (x_{n-2}, y_{n-2}); ...... etc. In other words, Equations 1 and 2 take into account the point at which the derivatives are desired and a number of succeeding points. Similarly Equations 3 and 4 consider the point investigated and a number of preceding points.

TABLE II

Bessels' Formulas for Derivatives

Derivatives	Number of Points on Curve to be Matched		
	3	5	7
	Formulas for Derivatives		
$y_n' = \left(\frac{dy}{dx}\right)_n$	$\frac{A_0}{h}$	$\frac{7A_0-A_1}{6h}$	$\frac{37A_0-8A_1+A_2}{30h}$
$y_n'' = \left(\frac{d^2y}{dx^2}\right)_n$	$\frac{2B_0}{h^2}$	$\frac{+15B_0-B_1}{6h^2}$	$\frac{245B_0-25B_1+2B_2}{90h^2}$
$y_n''' = \left(\frac{d^3y}{dx^3}\right)_n$		$\frac{A_1-A_0}{h^3}$	$\frac{-6A_0+7A_1-A_2}{4h^3}$
$y_n'''' = \left(\frac{d^4y}{dx^4}\right)_n$		$\frac{-6B_0+2B_1}{h^4}$	$\frac{-28B_0+11B_1-B_2}{3h^4}$
$y_n''''' = \left(\frac{d^5y}{dx^5}\right)_n$			$\frac{2A_0-3A_1+A_2}{h^5}$
$y_n'''''' = \left(\frac{d^6y}{dx^6}\right)_n$			$\frac{20B_0-10B_1+2B_2}{h^6}$

DISCUSSION: When establishing derivatives at any point of a curve, it is best practice to consider the same number of points on each side of the point investigated, whenever this is possible. Such a "symmetrical" procedure inherently leads to the most reliable results, provided there is no discontinuity within the region considered.

Inasmuch as Newton's equations (Equations 1 to 4) are "one-sided" their application can produce highly misleading results. How dangerous this is can be realized at once by checking Equation 1 against Equation 3 and Equation 2 against Equation 4 for the figures of the example illustrated in *Fig.* 1 and TABLE I. For the point under investigation ($x = 0.06$, $y = 4.54$), Equation 1 yields for the first derivative

$$\frac{dy}{dx} = \frac{1}{0.01}\left(0.01 - \frac{-0.01}{2} + \frac{0.01}{3} - \frac{0.4}{4}\right) = 0.83 \text{ in. per sec}$$

However, Equation 3 leads to

$$\frac{dy}{dx} = \frac{1}{0.01}\left(0.01 + \frac{0.00}{2} + \frac{0.05}{3} + \frac{0.11}{4}\right) = 4.92 \text{ in. per sec}$$

The discrepancy between the values of the slope as calculated by Equations 1 and 3 is so great that not even an intelligent compromise can be made.

The situation is even worse for the second derivative. Equation 2 yields 170 in. per sec², while Equation 4 gives 1583 in. per sec².

It should be noted (see *Fig.* 1) that the nature of the curve in the vicinity of the point investigated is not particularly complicated. Hence, the discrepancies found between the results obtained by Newton's equations can only be attributed to the basic characteristics of these equations. While Newton's equations are the best approach for investigating the slope at or very near the end points of a curve, they are not well suited for the general case where the curve extends in both directions from the point under consideration. In the general case Bessel's formulas, which are developed in the following, should be used.

APPROPRIATE FIVE-TERM POWER SERIES: Algebraic power series, taking into account the same number of

Fig. 1—Portion of function represented by Table I, showing the variation in calculated slope using Equation 1 (S_1), Equation 3 (S_3), and the appropriate five-term power series (S_a). The curve represents the series matching five points, and is shown solid within the range of these points

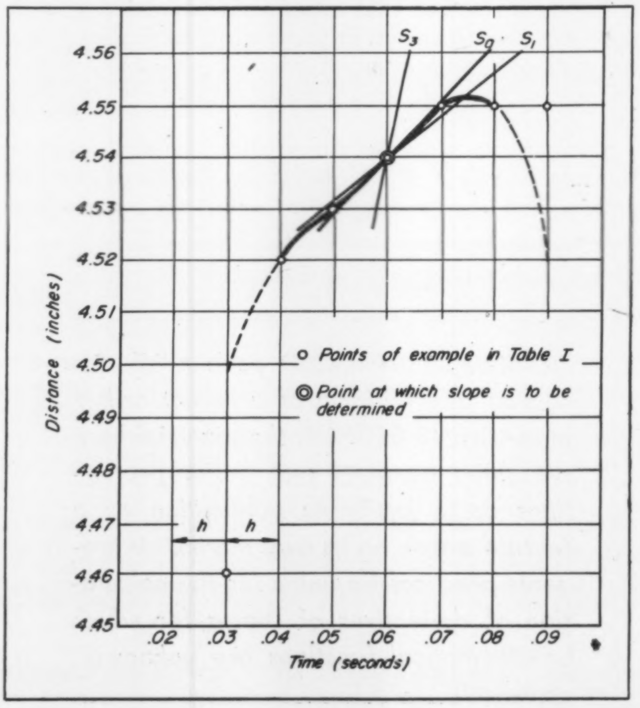

TABLE III—Function $y = e^{-x}$ and Successive Differences

x	*y*	*a*	*b*	*c*	*d*	*e*	*f*
—6.00	+403.4288						
		—255.0156					
—5.00	+148.4132		+161.1200				
		— 93.8150		—101.8176			
—4.00	+ 54.59815		+ 59.3024		+64.3913		
		— 34.51261		— 37.4863		—40.6393	
—3.00	+ 20.08554		+ 21.81613		+23.6920		+25.6684
		— 12.69648		— 13.7943		—14.9709	
—2.00	+ 7.38906		+ 8.02570		+ 8.7211		
		— 4.67078		— 5.0732			
—1.00	+ 2.71828		+ 2.95250			*For Equation 3*	
		— 1.71828					
00	+ 1.00000						
		— 0.63212					
+1.00	+ 0.36788		+ 0.39958			*For Equation 1*	
		— 0.23254		— 0.25259			
+2.00	+ 0.13534		+ 0.14699		+ 0.15968		
		— 0.08555		— 0.09291		— 0.10096	
+3.00	+ 0.04979		+ 0.05408		+ 0.05872		+ 0.06386
		— 0.03147		— 0.03419		— 0.03710	
+4.00	+ 0.01832		+ 0.01989		+ 0.02162		
		— 0.01158		— 0.01257			
+5.00	+ 0.00674		+ 0.00732				
		— 0.00426					
+6.00	+ 0.00248						

points on each side of the point investigated, are the logical approach to the problem of establishing the derivatives by numerical methods. It is assumed again that the curve is "smooth" within the region considered. In general, test data are not sufficiently accurate to warrant taking into account more than five consecutive points. The power series thus has to satisfy the point investigated and two points on each side of it. Such a power series has five terms, including one with x^4.

It can be shown that the series

$$y=4.13+27.5833x-745.8333x^2+9,166.6667x^3-41,666.6667x^4$$

satisfies the following five points of the example in TABLE I:

$x_{n-2} = 0.04,\quad y_{n-2} = 4.52$
$x_{n-1} = 0.05,\quad y_{n-1} = 4.53$
$x_n = 0.06,\quad y_n = 4.54$ (the point investigated);
$x_{n+1} = 0.07,\quad y_{n+1} = 4.55$
$x_{n+2} = 0.08,\quad y_{n+2} = 4.55$

The derivatives at the point investigated are calculated from the foregoing power series as:

$$\left(\frac{dy}{dx}\right)_n = 1.0833 \text{ in./sec}$$

$$\left(\frac{d^2y}{dx^2}\right)_n = 8.3333 \text{ in./sec}^2$$

$$\left(\frac{d^3y}{dx^3}\right)_n = -5{,}000 \text{ in./sec}^3 \text{ and}$$

$$\left(\frac{d^4y}{dx^4}\right)_n = -1{,}000{,}000 \text{ in./sec}^4$$

The slope of 1.0833 in. per sec is plotted in *Fig* 1, and appears quite plausible. For comparison, the slopes calculated from Equations 1 and 3 are also shown.

BESSEL'S FORMULAS: The formulas for the derivatives, taking into account the same number of points on each side of the point investigated, can be established by expanding power series with the arguments x_n, (x_n+h), (x_n-h), (x_n+2h), (x_n-2h), etc. The labor involved in these algebraic operations is greatly reduced by the use of Taylor's series². The differences *a* between successive values *y* of the expanded power series are readily calculated. It is then found convenient to introduce combinations of differences *a* located correspondingly with respect to the point investigated:

$$A_0 = \frac{a_n + a_{n-1}}{2} = y_n'h + y_n'''\frac{h^3}{3!} + y_n'''''\frac{h^5}{5!} + \dots\dots\dots\dots$$

$$A_1 = \frac{a_{n+1} + a_{n-2}}{2} = y_n'h + 7y_n'''\frac{h^3}{3!} + 31y_n'''''\frac{h^5}{5!} + \dots\dots\dots$$

$$A_2 = \frac{a_{n+2} + a_{n-3}}{2} = y_n'h + 19y_n'''\frac{h^3}{3!} + 211y_n'''''\frac{h^5}{5!} + \dots\dots$$

etc., and

$$B_0 = \frac{a_n - a_{n-1}}{2} = y_n''\frac{h^2}{2!} + y_n''''\frac{h^4}{4!} + y_n''''''\frac{h^6}{6!} + \dots\dots\dots$$

$$B_1 = \frac{a_{n+1} - a_{n-2}}{2} = 3y_n''\frac{h^2}{2!} + 15y_n''''\frac{h^4}{4!} + 63y_n''''''\frac{h^6}{6!} + \dots\dots$$

$$B_2 = \frac{a_{n+2} - a_{n-3}}{2} = 5y_n''\frac{h^2}{2!} + 65y_n''''\frac{h^4}{4!} + 665y_n''''''\frac{h^6}{6!} + \dots$$

etc., where

$$y_n' = \left(\frac{dy}{dx}\right)_n,\quad y_n'' = \left(\frac{d^2y}{dx^2}\right)_n,\quad \text{etc.}$$

The derivatives in terms of A_0, A_1 A_2, ... and B_0, B_1, B_2, ... can now be calculated from the foregoing equations by successive elimination. Obviously, the more points of a test curve the power series is to match, the higher the degree of the power series, the greater the number of simultaneous equations that must be solved, and the greater the number of terms in each equation that must be considered. The resulting formulas for the derivatives are presented in TABLE II; these formulas are known as Bessel's formulas.

It is of particular interest to notice that the formulas for the odd derivatives contain only the averages *A* of corresponding differences *a*, while the formulas for the even derivatives contain only the half-differences *B* between corresponding differences *a*. Bessel's formulas permit the calculation of higher orders derivatives without first computing the derivatives of lower order. This advantage claimed for Newton's formulas is thus also realized. Furthermore, Bessel's formulas do not require the computation of successive differences b, c, d, etc., which enter Newton's equations.

The simple combinations A and B were introduced into the formulas of TABLE II primarily to make them more compact. They can be replaced conveniently by the respective a terms. This is preferable for certain methods of machine calculation. In this case, only the values of y and a must be established as a prepreliminary to finding the derivatives. For instance, for a power series that is to match five points of a curve, the second derivative at the center point is

$$y_n'' = \left(\frac{d^2y}{dx^2}\right)_n = \frac{15a_n - 15a_{n-1} - a_{n+1} + a_{n-2}}{12h^2}$$

This formula can be rearranged for convenience so that tabular values are used instead of differences:

$$y_n'' = \frac{-y_{n-2} + 16y_{n-1} - 30y_n + 16y_{n+1} - y_{n+2}}{12h^3}$$

A 10-place calculating machine will usually accept all figures given in the numerator of the foregoing formula at one time, which means that y_n'' can be computed directly from the table with one setting of the machine, and without writing anything down, thus saving time and reducing the hazard of error.*

The formulas for a five-point match of TABLE II, applied to the example in TABLE I, yield the same values as were found above by direct derivation of the five-term power series.

TABLE V

Derivatives for the Function $y = e^{-x}$

(as found from Bessel's formulas)

Derivatives	Number of Points on Curve to be Matched by Power Series			Correct Values
	3	5	7	
$y' = \frac{dy}{dx}$	−1.1752	−0.9624	−1.0087	−1.00000
$y'' = \frac{d^2y}{dx^2}$	+1.0862	+0.9878	+1.0021	+1.00000
$y''' = \frac{d^3y}{dx^3}$		−1.2764	−0.9299	−1.00000
$y'''' = \frac{d^4y}{dx^4}$		+1.1798	+0.9662	+1.00000
$y''''' = \frac{d^5y}{dx^5}$			−1.3864	−1.00000
$y'''''' = \frac{d^6y}{dx^6}$			+1.2813	+1.00000

TABLE IV—**Derivatives for the Function $y = e^{-x}$**

(as found by Newton's formulas)

Derivatives	Equation	Number of Points on Curve to be Matched by Power Series					Theoretical Values
		3	4	5	6	7	
$y' = \frac{dy}{dx}$	1	−0.83191	−0.91611	−0.95603	−0.97622	−0.98686	−1.00000
$y' = \frac{dy}{dx}$	3	+0.29797	−1.39310	+0.78717	−2.20701	+2.07106	−1.00000
$y'' = \frac{d^2y}{d^2x}$	2	+0.39958	+0.65217	+0.79854			+1.00000
$y'' = \frac{d^2y}{d^2x}$	4	+2.95250	−2.12070	+5.87360			+1.00000

It is realized at once that the formula for the first derivative obtained by considering an appropriate power series matching three consecutive points of a curve, namely

$$y_n' = \left(\frac{dy}{dx}\right)_n = \frac{a_n + a_{n-1}}{2h}$$

is equivalent to Professor Balleisen's graphical construction of the slope (drawing the tangent parallel to the chord connecting the points on either side of the point investigated).

It would be expected that the accuracy of determining derivatives increases with the number of consecutive points on the curve that are taken into account. While this is true for curves representing mathematical functions, it does not hold generally. A certain scatter of the points, or waviness of the curve, as is frequently the case with graphical records, makes it mandatory to consider only a limited number of consecutive points, and possibly to increase the spacing between points. For instance, in the example in TABLE I, the first derivatives at point ($x = 0.06$, $y = 4.54$) calculated from Bessel's formulas are as follows:

Power series matching 3 Points of Curve: $y' = 1.000$
Power series matching 5 Points of Curve: $y' = 1.083$
Power series matching 7 Points of Curve: $y' = 1.200$

The differences in the results are not due to poor convergency of Bessel's formulas, but due to the particular nature of the curve (see *Fig.* 1). Such curves are often obtained by graphical instruments, and in most cases one is not justified in taking into account more than five consecutive points for establishing derivatives. This means that, generally, only derivatives up to the fourth can be calculated with a reasonable chance of accuracy. However, the "smoothness" of the curve determines how far one can go, and it takes some experience on the part of the operator to decide where to stop. Under certain conditions (scatter), it is advisable to smooth out the test record prior to starting the numerical procedure.

In some cases, particularly when records from an intermittent recording instrument are to be analyzed, it is of interest to establish the power series itself.

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* The authors are indebted to Mr. Macon Fry for the rearranged formula and accompanying discussion.

This is a convenient means of finding the mathematical function corresponding to the recorded test data. The coefficients of the power series

$$y = y_0 + qx + rx^2 + sx^3 + tx^4 + \dots\dots\dots\dots$$

can be found from the co-ordinates of and the derivatives at any point by means of the formulas:

$$y_0 = y_n - x_n y'_n + \frac{1}{2}x_n^2 y_n'' - \frac{1}{6}x_n^3 y_n''' + \frac{1}{24}x_n^4 y_n'''' - \quad \dots$$

$$q = y_n' - x_n y_n'' + \frac{1}{2}x_n^2 y_n''' - \frac{1}{6}x_n^3 y_n'''' + \dots\dots\dots\dots$$

$$r = \frac{1}{2}y_n'' - \frac{1}{2}x_n y_n''' + \frac{1}{4}x_n^2 y_n'''' - \dots\dots\dots\dots$$

$$s = \frac{1}{6}y_n''' - \frac{1}{6}x_n y_n'''' + \dots\dots\dots\dots$$

$$t = \frac{1}{24}y_n'''' - \dots\dots\dots\dots$$

Validity of these formulas can be verified by successive derivation of the power series and solving for the coefficients. When the foregoing formulas are applied to the example, the five-term power series presented earlier in this article is obtained.

Convergency of Formulas: Convergency is one of the most important considerations in the choice of formulas derived from power series. Convergency can be examined by applying the formulas to mathematical functions, and choosing a relatively great spacing between consecutive points. The curve corresponding to

$$y = e^{-x}$$

may be examined at the point ($x = 0$, $y = 1$) by considering points of the curve with abscissas $x_n = 0$, $x_{n+1} = 1$, $x_n - 1 = -1$, $x_{n+2} = 2$, $x_{n-2} = -2$, $x_{n+3} = 3$, $x_{n-3} = -3$, etc. The respective values of y obtained from mathematical tables, and a table of successive differences corresponding to Table I are presented in Table III. Newton's and Bessel's formulas can now be applied to determine the derivatives. For comparison, the mathematically correct derivatives are also established: The function chosen can be represented by the power series[2]

$$y = e^{-x} = 1 - x + \frac{x^2}{2!} - \frac{x^3}{3!} + \frac{x^4}{4!} - \dots\dots\dots\dots$$

The odd derivatives for $x = 0$ are $y' = y''' = y''''' = \dots\dots = -1$, and the even derivatives at this point are $y'' = y'''' = y'''''' \dots\dots = +1$.

Table IV shows the first and second derivatives calculated by Newton's equations. As the number of matched points is increased, Equation 1 converges satisfactorily well toward the correct value, although not as well as the corresponding Bessel's formula. Convergence of Equation 2 is poor, while Equations 3 and 4 lead to alternating terms of increasing absolute value. They are thus not convergent in this particular example.

Table VI
Coefficients in Power Series

Coefficients	Number of Points on Curve to be Matched by Power Series			Correct Values
	3	5	7	
y_0	1.0000	1.0000	1.0000	1.0000
q	−1.1752	−0.9624	−1.0087	−1.0000
r	+0.5431	+0.4939	+0.50010	+0.50000
s		−0.2127	−0.1550	−0.1667
t		−0.04916	+0.04026	+0.04167
u			−0.01155	−0.008333
v			+0.00178	+0.00139

Table V shows the derivatives as calculated by Bessel's Equations (Table II). As the number of matched points is increased, the results converge satisfactorily toward the correct values. Two trends are of interest: First, for a given number of points of the function that are matched by the power series, accuracy of determination of both the even-order and the odd-order derivatives decreases as the order of derivatives increases. This first trend holds generally; it is brought about by the basic nature of the problem. Second, for a given number of points of the function that are matched by the power series, any even-order derivative is determined to somewhat better accuracy than the next lower odd-order derivative. This second trend is not inherent with the problem or the formulas of Table II, but depends on the nature of the function in the vicinity of the point investigated.

Both numerical examples indicate that for determining the first and second derivatives, it is good practice to work with formulas derived from power series matching five points. This leads to the conclusion that for computing the third and fourth derivatives, one should preferably choose the formulas based on power series matching seven points, etc. Here again, the characteristics of the test curve determine how far one can reasonably proceed. In some cases, one is not even justified in computing higher derivatives than the second.

Coefficients of the power series matching the function $y = e^{-x}$ at 3, 5, or 7 points can now be calculated by means of the derivatives shown in Table V and the foregoing formulas. These formulas are particularly convenient in the case of $x = 0$. The results are shown in Table VI. It is realized again that convergency toward the correct values is satisfactory as the number of matched points is increased. The remarks of the previous two paragraphs, regarding accuracy of determination and justification in working with higher degree power series, also apply here.

References

1. J. B. Scarborough—*Numerical Mathematical Analysis*, Johns Hopkins Press, Baltimore, 1930.
2. I. S. and E. S. Sokolnikoff—*Higher Mathematics for Engineers and Physicists*, McGraw-Hill Book Co., New York, 1941.

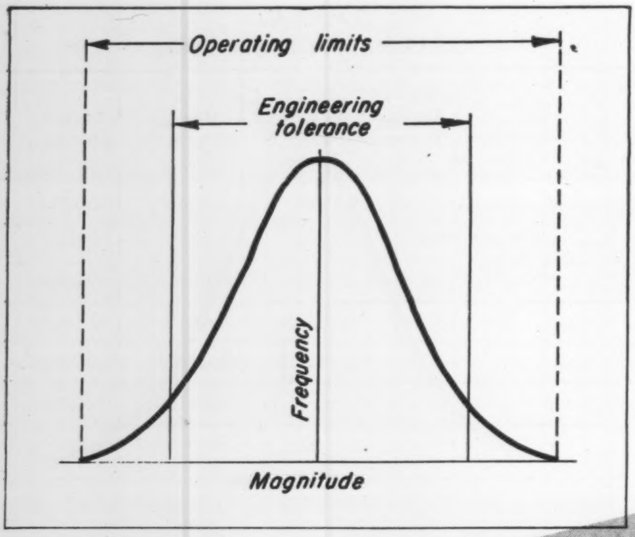

Fig. 1—Typical distribution curve of variations, the basis for statistical analyses, can be made of much practical value in design

Specifying

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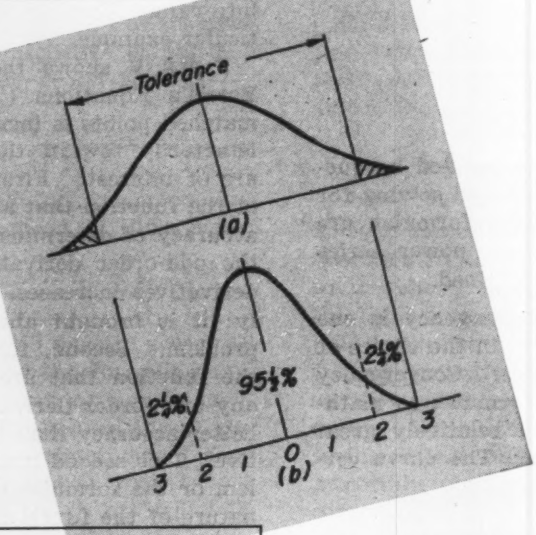
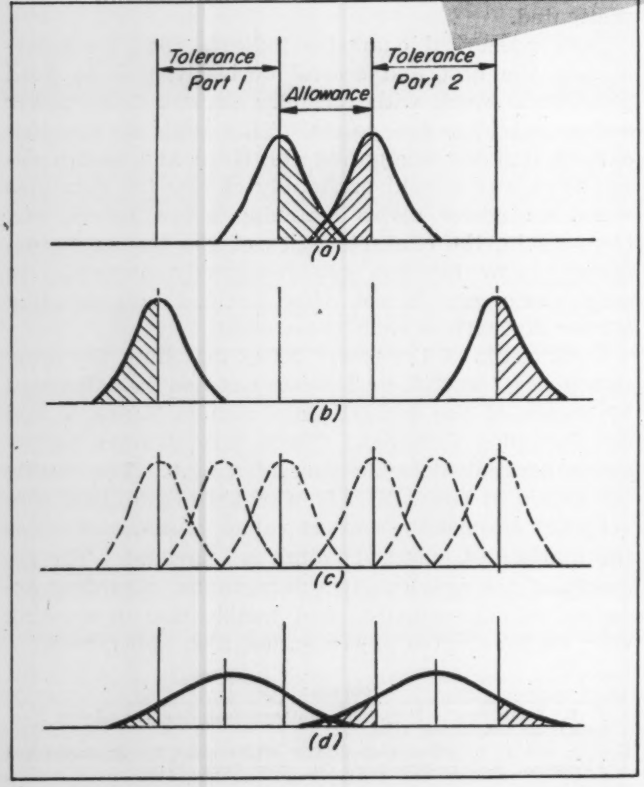


Fig. 3 — Uncontrolled production curve with scrap shaded is shown at (a) as compared to a typical controlled distribution at (b)

Fig. 2—Distribution trends followed by uncontrolled operations on two mating parts. Worst conditions at lower and upper limits are shown at (a) and (b), total fluctuation at (c) and overall distribution at (d)



PRIOR to the present machine age, the fit of parts was not a serious consideration in manufacturing. Each worker was an individual artist responsible for making and assembling units which would function as required. With the advent of mass production, conditions changed. It was no longer a case of selective assembly of one part with another by one worker, but a question of assembling any one of a group of parts with any one of the mating parts. This required precise control of dimensions and led to establishing tolerances to express the variation which the engineer believed could be allowed in a dimension and still retain this requirement for assembly.

Since that day industry has made tremendous strides, not only improved machinery to meet the new demands but also in more precise methods of measurement to control the new machinery. First the "Go" gage, then the "Go-No Go" gage, followed by the micrometer and an ever-increasing number of precision instruments were developed to meet every demand of production. Each of these steps has provided the design engineer with new information

Design Tolerances

. . . by statistical analysis permits the establishment of satisfactory values on a sound, efficient design and production basis

essential to his work. With the closer control of measurement, interchangeability has become more positive so that individual parts can be designed for manufacture at any plant and brought together for assembly with every assurance that the parts will fit.

With a competitive market in view, the design engineer has another problem which must be coordinated with this growth and expansion of manufacturing—namely, cost. It might be said that there are two major purposes in the production of any machine or product:

1. To fill an existing or creatable demand with a product that will be acceptable to the user
2. To produce that product at a price that is in economic balance with its function.

In simple terms this merely means to build a workable product that can be sold at a profit. While all functions of a company combine to produce these two results, the actual result is determined to a high degree, if not positively, by the engineer in the design of the product. After a product has been designed and materials determined, the engineer must prescribe how the completed unit and its component parts must be made in order to fulfill the two major purposes outlined above: (1) That it will work satisfactorily, and (2) that it can be produced economically. The tool used by the engineer to meet these condtions is the tolerance which is, in effect, the specified allowance from a set figure which can be accepted as meeting requirements for the unit.

> ***"While all functions of a company combine to produce a workable product that can be sold at a profit, the actual result is determined to a high degree, if not positively, by the engineer in the design of the product."***

In design work there will usually be one tolerance best fitted to meet both considerations of acceptance and cost. It must be close enough to guarantee the correct functioning of the unit in relation to the whole, and wide enough to allow the lowest production cost. As a tolerance is reduced, the positive functioning of the part may improve but the cost of production will increase. Conversely, when a tolerance is increased, the positive functioning of the part decreases but the cost of production will also decrease. The engineer, therefore, must determine that tolerance which will give the greatest freedom to production and yet produce an acceptable product. Such a tolerance ordinarily cannot be picked out of the air or set by some assistant draftsman with the aid of a set of tables. It must be determined from a study of all conditions that affect that individual unit, its relation to mating parts, interchangeability in the field, service life, as well as the machinery, equipment, and personnel available for its production. For this reason, there is no rule of thumb that can be laid down and applied promiscuously to design drawings. The tolerance is the link between design and production and must be determined through the cooperative action of both.

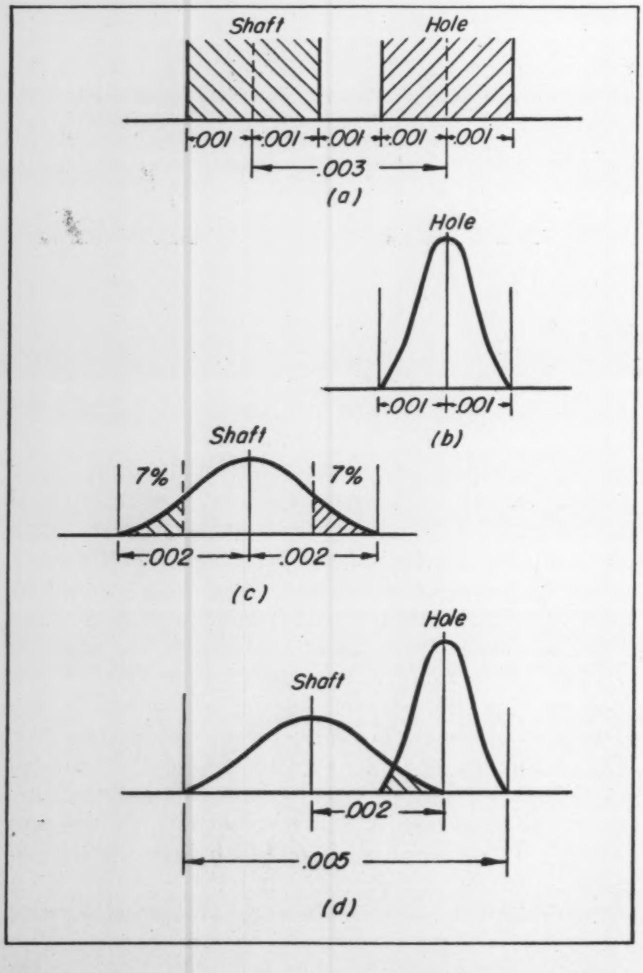
> ***"The tolerance is the link between design and production and must be determined through cooperative action of both."***

The relatively new science of statistical control offers a medium of collective action that is not otherwise available. This method when applied to production supplies the engineer with specific data which are essential to the proper determination of tolerances. When applied to design by the engineer, it supplies production with the greatest freedom and a more comprehensive picture of the work that must be done. The basic principle of statistical control is that, while all things vary, this variation follows a definite pattern which can be determined and used in the design, production, and inspection of a product. This pattern is known to most engineers as the distribution curve, *Fig.* 1, and is a picture of the actual variations and frequency of occurrence present in a process under existing operating conditions. The extremes of this curve determine the limits of variation in the operation, or the operating limits, and the area under any segment of the curve represents the percentage of parts which will normally be produced within the limits of that segment. While all curves will not be uniform or normal as shown, most *controlled* operations approach normalcy so that this condition can be assumed until more specific data are available.

Only a small amount of production data is required to determine those properties of a distribution curve which are used in the determination of tolerances. The engineer is primarily interested in the width of the curve as this determines the degree of variation under existing operating conditions. He must expect some units to be as small as indicated by the lower-tolerance tip of the curve and some to be as large as the upper-tolerance tip. For practical design purposes he can be assured that with *controlled* production, the controlled measurements will all fall within these extremes and none will be larger or smaller than indicated. With this assurance it is possible to determine from the function of the part whether it will produce an acceptable product. If the desired tolerance is greater than the spread of the curve, the engineer can rest assured that no trouble should develop in the controlled (quality control charted) production of the unit.

> *"The basic principle of statistical control is that, while all things vary, this variation follows a definite pattern which can be determined and used in design."*

Fig. 4—Specific design tolerances for a shaft and hole are indicated at (a) while practical shop tolerances for the hole and shaft are shown at (b) and (c). Under statistical control, shop tolerances can be used by overlapping with only four chances in one thousand of interference



However, in this case the tolerances should not be reduced to the limits of the curve, but be left at the *greatest* allowable value so as to give production the greatest freedom in setup and run time. If the converse is true, and the desired tolerance is less than the spread of the curve, *Fig.* 1, the engineer knows that all units cannot be produced to this requirement under existing operating methods and some positive decision must be made before the parts are released for production. Either the tolerance must be increased to the width of the curve, at least, or the method of production must be improved or changed to bring the limits of the curve within the tolerance. Otherwise a percentage of scrap and rework must be accepted as normal to the production of the unit.

Inasmuch as the curve is based on frequency of occurrence, the area under any section of the curve represents the actual percentage of parts which will normally be produced within the limits of the area. For example, as the curve is symmetrical, 50 per cent of the parts will fall on either side of the mean, with approximately 34 per cent in the first, 14 per cent in the second, and 2 per cent in the outer third of each half of the curve. Other percentages for areas under a normal curve may be calculated or obtained from tables in standard reference books. These percentages hold true for all normal curves regardless of the width or the number of parts represented by the curve.

While variation is always present in all operations its degree is only known and therefore can only be used in *controlled* production. Without statistical control in the shop the distribution curve of an operation is constantly changing in position and shape due to constantly changing operating conditions and there is no assurance that the curve produced in the past will be reproduced in future operation. Under these conditions the engineer must of necessity assume the worst conditions and set tolerances accordingly. He must assume, for example, in the mating of two parts, that both parts may be produced close to the lower limit, *Fig. 2a,* or to the upper limit, *Fig. 2b,* and that inspection has rejected the unacceptable units shown under the shaded portions. Actually uncontrolled production will usually fluctuate from one extreme to the other as in *Fig 2c.* The combination of all of these fluctuations results in wide distribution curves with a percentage of parts outside all tolerances, *Fig. 2d.* For this reason the engineer has no recourse other than to set tolerances which will hold all parts produced to rather close and exacting limits. If, however, the shop is operating under statistical control, positive and exact information will be available in the form of the distribution curve of that operation. Because this distribution curve will be controlled in its movement, intelligent and economical tolerances may be determined with the positive assurance that future production will reproduce past performance.

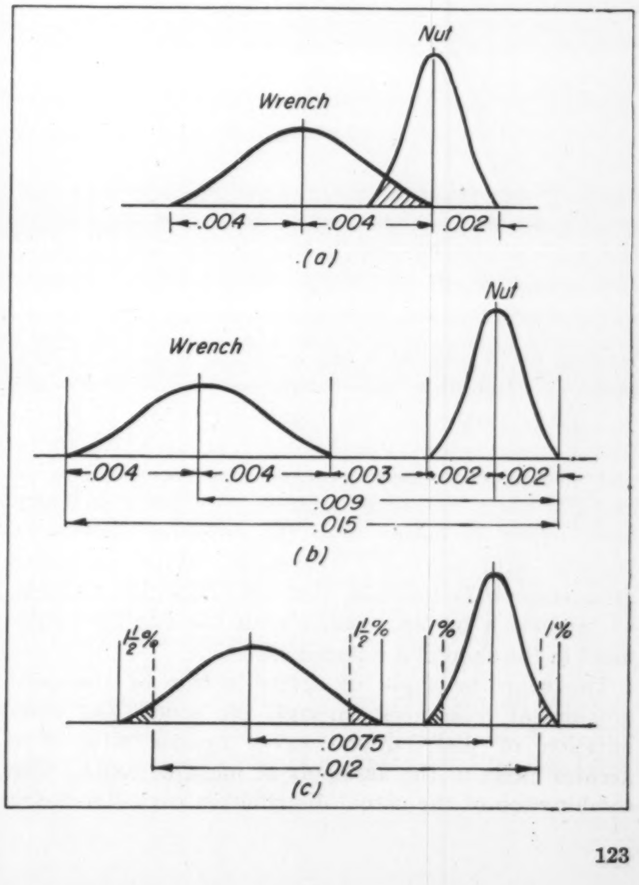
From this it might appear that action by the engineer is dependent on shop practice. This is not entirely true. When tolerances have been set by the engineer for uncontrolled production—the usual practice—the shop cannot adopt controlled production without seriously reducing its freedom of operation. For example, uncontrolled production will in most cases produce some parts that are outside the tolerance. These may be found and rejected through 100 per cent inspection, *Fig. 3a.* In controlled production, on the other hand, if the operating limits coincide with the tolerances, so that no defects will be produced, 95½ per cent of all parts will fall within two-thirds of the tolerance *Fig. 3b.* This practically cuts the freedom of production by one-third. For this reason the use of statistical control becomes a cooperative effort. The engineer cannot set economical tolerances without knowing that production will be controlled, and the shop cannot afford controlled production without relief from engineering when required. However, the advantages to be gained through cooperative action are so great that it is well worth the effort required.

> **"Statistical control will provide data on production operations that will eliminate opinions and establish a sound basis for decisions."**

Statistical control will provide data on production operations that will eliminate opinions and establish a sound basis for decisions by both the engineering and production personnel. Suppose, for example, that a shaft and hole were designed for assembly. The engineer determined from knowledge of the function of the unit that clearance between mating parts could be no greater than 0.005-inch and that the average fit should be as close as possible. To meet these conditions and give the shop some freedom, the tolerance of each part was set at plus or minus 0.001-inch with a minimum clearance of 0.001-inch between parts, *Fig. 4a.* This set the average clearance between mating parts at 0.003-inch. The first units produced by the shop under controlled production showed that the hole could be held easily to its tolerance of plus or minus 0.001-inch, *Fig. 4b,* but that the variations in the shaft diameters under existing conditions were plus or minus 0.002-inch, *Fig. 4c.* To meet the original engineering tolerance all shafts would require 100 per cent inspection to cull out the under and oversize shafts. There would be approximately 7 per cent of the shafts that were small and therefore scrap, and another 7 per cent that were too large and would require rework. Under these conditions the cost of the unit would be excessive. The only alternative would be to purchase new machinery and equipment involving a substantial investment and a costly delay.

Could the shaft be redesigned and the tolerance changed? With conventional inspection and control the answer would have to be "no" if the original design was sound. With statistically controlled production and a knowledge of statistical methods the engineer could use these production data to determine a positive and sound answer to the problem. In order to hold to the orginal tolerance and have no assembly with a clearance greater than 0.005-inch, the outside extremes of both curves must be held within this dimension. With the hole varying 0.002

Fig. 5—Overlapping of tolerances with wrench manufacture is impractical (a), but by reducing the mean allowance (b) as at (c) a practical solution is obtained



(plus or minus 0.001-inch) and the shaft 0.004-inch it is immediately evident that the two curves will overlap by 0.001-inch, *Fig. 4d.* This means that some of the shafts would be larger than the hole into which they must fit.

In general practice, a tolerance that would allow a shaft larger than the hole in which it must fit would not be considered practical. However, with controlled production such an overlapping of tolerances is not only practical but often essential and most economical. When assembly of the units is random, that is, when there is an equal chance of selecting any one of either part during assembly, the chances of picking a large shaft and a small hole at the same time follow the law of probability. In this case, because there are so few parts at the extremes of a normal distribution on the average this would occur only four times in a thousand assemblies and would not be serious. It would only mean dropping one part and picking another. Therefore the overlapping of tolerances is the practical solution to this problem. Doubling the tolerance of the shaft not only gives production the required freedom of operation but also eliminates 14 per cent defective units, and produces a closer average fit. The average fit between parts has been reduced from 0.003 to 0.002-inch, which is better than the engineer considered possible with available equipment. With controlled production it is possible, through cooperative action, to produce a better product with the regular equipment in the shop at a reduced cost.

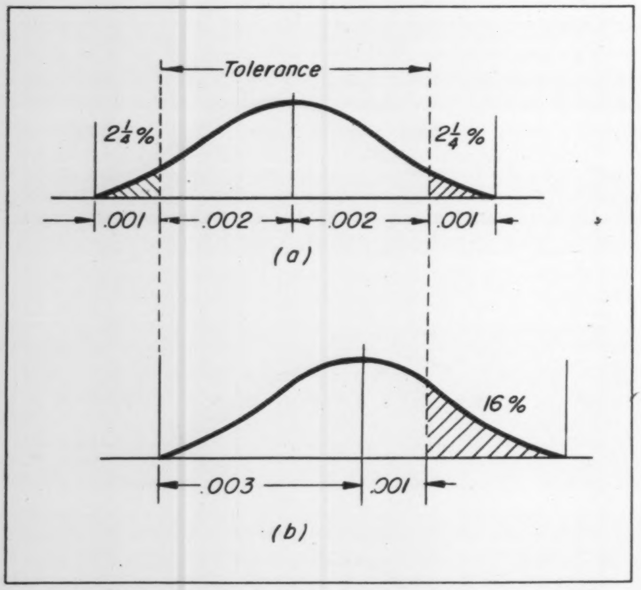


Fig. 6—Where defectives are produced (a), inspection must be 100 per cent. Where rework cost is low the distribution curve can be adjusted (b) so as to eliminate all actual scrap by reworking oversize parts

The same principle of determination of the most economical tolerances through the study and combination of distribution curves applies with even greater effect in the assembly of multiple units. The combination of the actual distribution curves for each mating part, as determined from production, will show the total variation that must be expected in the assembly of the parts. The total variation of the assembly will be much less than the sum of the variations of the component mating parts and will set the minimum tolerance that is possible in the plant under existing conditions with no chance of interference on assembly. If this fails to meet the standard desired by the engineer, it may be possible to again overlap some of the distribution curves for the individual parts so as to meet the standard with only a slight chance of interference on assembly. Conversely, if a tolerance is predetermined for an assembly, the allocation of that tolerance to the individual units in proportion to the actual needs of the shop is again possible through an analysis of the individual distribution curves. In most cases this will show that it is possible to allow the shop much greater freedom on individual parts than would appear to be practical from a conventional interpretation of the assembly data.

Overlap Without Random Assembly

As stated earlier, this system of overlapping distribution curves can be applied when the assembly of units is random. It cannot be applied in the same manner when assembly is not random. For example, if the jaws of an open-end wrench were designed with tolerances overlapping those of the nut, the purchasers of all wrenches represented by the overlapping section of the distribution curve for the wrench, *Fig. 5a,* would have tools that would function on only a part of the nuts. The worst wrench produced would fit only 50 per cent of the nuts. Naturally this would not be practical and such a design decision would be as disastrous as the previous example was good. The solution to this problem, however, may again be solved through the use of statistical control. In this case the clearance between the wrench and the nut is the critical dimension that must be maintained. Assume a minimum clearance of 0.003-inch for a good fit between the smallest wrench and the largest nut. If the nuts have a variation of plus or minus 0.002-inch and the wrenches of plus or minus 0.004-inch, the distribution curves show immediately that the average clearance between wrenches and nuts will be 0.009-inch, *Fig. 5b.* It is also apparent that some of the wrenches will have as much as 0.015-inch clearance with some of the nuts. If this maximum or the average clearance is too great, some compromise will be needed.

As the wrench manufacturer has no control over the nuts, this distribution curve must be held and cannot be adjusted to improve the fit. However, the curve for the wrenches can be controlled so that the engineer may change its position to get the best results in the finished product. If the average of this curve is moved closer to that of the nuts, *Fig. 5c,* the maximum and average clearances will be reduced but the minimum will also be reduced. While this is not desirable, it may not be critical. If the minimum clearance is reduced from 0.003 to 0.0015-inch, the average fit and maximum clearance will also be reduced by the same amount. Under these conditions there will be about 1.5 per cent of the wrenches which will have less than 0.003-inch clearance on about 1 per cent of the nuts. This means that while all wrenches will fit all nuts, there will be about 1.5 per cent of all buyers who will own wrenches that will be tight on about 1 per cent of the nuts. To offset this, the change will reduce the maximum clearance so that about 1.5 per cent of wrenches will fit loosely on 1 per cent of nuts. However, the average fit between wrenches and nuts has been reduced from 0.009 to 0.0075-inch. It may be that the slight inconvenience caused by the few wrenches which would not fit perfectly from an engineers' point of view would be commercially acceptable in view of the general improvement in the product as a whole. Here again, a study of the distribution curves allows the engineer to make a sound decision on design characteristics.

The final and perhaps the most common example of the practical application of statistical control to design is in the resolving of proper limits when the shop cannot produce all parts to tolerance and the engineer cannot increase them. Under these conditions some defective parts must be produced and therefore all parts must be inspected 100 per cent, *Fig. 6a*. The problem here is to reduce the cost of these rejections to the minimum. Here again the distribution curve will provide the correct solution. When the cost of the parts is high and rework cost is low, it is possible to plan production so that all parts rejected will be reworkable and none scrap. The distribution curve is set with the lower tip at the minimum acceptable dimension, *Fig. 6b*. This will result in a new nominal dimension with unequal tolerances, as minus 0.003 and plus 0.001-inch. In this case production must operate to the nominal and not to the mean of the tolerances in order to produce the desired results. The percentage of defective parts will be increased by this change but if the cost of rework on the increased number of parts is less than the cost of the scrap which would otherwise be produced, it is economical. This method is not economical when the cost of the part is low and rework cost is high. A similar shift of the curve to produce all scrap parts would only increase the total number of parts which would be outside the tolerance. It would be more economical to hold the mean, and scrap both over and undersize parts, *Fig. 6a*. This is true in most cases where production cannot meet tolerances as maintenance of production close to the mean will produce the smallest number of defective parts.

> *"With controlled production it is possible to produce a better product at reduced cost with the regular equipment in the shop."*

The examples chosen for this article are but a few of many and are for the purpose of illustrating the use of statistical methods by the design engineer. While many tolerances are not critical and therefore do not require a statistical study to determine the ultimate for acceptance and cost, even those tolerances, if considered in the form of a distribution curve, take on a new meaning. This picture of the variation which always exists in a production process illustrates what dimensions will actually look like in the final product. The more important the unit, the more precise the picture must be and the more useful statistical control becomes. The following results may be expected from the use of this method of determination of tolerances:

1. The engineer will have the facts from which he can determine the most economical tolerances, consistent with the use of the part
2. Production will know that tolerances determined in this manner represent actual shop conditions
3. Inspection can be reduced to a minimum
4. Many parts which are now rejected as being outside tolerances as conventionally set will become usable
5. Costs will decrease
6. Engineering, production, and inspection will become a single, co-operative unit.

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Remote-Control Gunnery Target

CAPABLE of speeds of 220 mph but weighing only 300 pounds, the U. S. Air Force's newest flying target, the OQ-19A remotely controlled target plane will fly to altitudes of 20,000 feet for as long as one hour without refueling. It can be operated anywhere within the line of sight, and telescopic aids can be used for increasing the operating range. Remotely controlled from the ground or air, the target is capable of high-speed dives, loops, rolls, wingovers, and steep banks to simulate fighter aircraft maneuvers. At a 200-yard range the plane, with a 12-ft wing span and 10½-ft length, has the appearance of a normal-sized fighter at 500 yards.

The 80-pound, 4-cylinder, air-cooled engine powering the plane operates on the two-stroke principle and develops 60 hp on a mixture of gasoline and oil. It is launched by a rocket that boosts it along a 60-ft catapult to a speed of 80 mph for takeoff. A hydraulic snubbing device stops the rocket car used in the launching within a distance of 4 ft. In landing, a cargo type parachute in the plane can be released by the operator, or the parachute release can be automatically actuated by interruption of the radio carrier wave as would happen in the case of a direct hit. The target plane is manufactured by the Radioplane Co., Van Nuys, Calif.

Management and Engineering

A symposium of three articles dealing with engineering design and its importance in achieving satisfactory and economical manufacture, based on addresses presented at the recent Conference on Production of the American Management Association, in Chicago

All major problems of engineering, production and sales are broadly discussed and brought to a successful conclusion by production committee action wherein all phases of management are represented

Co-ordinating Engineering, Production and Sales

By H. B. Spackman
Executive Vice President
Lyons Metal Products Inc.
Aurora, Illinois

LACK of systematic communication between executives of the same rank within a company appears to be the biggest factor contributing to lack of proper co-ordination. Actual surveys show that lack of proper co-operation between engineering, production and sales has cost some companies hundreds of thousands, or in some cases, even millions of dollars per year. The logical procedure, therefore, is to set up some sort of system that will effect daily and systematic co-ordination between all major phases of engineering, production and sales.

Our plants operated at full capacity throughout the war, serving practically every branch of the Government and armed forces, through a total of four thousand different contracts, some of which called for revolutionary new processes, equipment, and skill, completely foreign to our production department. Through necessity, we stumbled onto a so-called war production committee idea as authorized by top management, hoping that this medium would help to unravel the mess in which we found ourselves. Every major division in the company had representation on this committee through which all war production inquiries flowed. This, of course, included production, processing, engineering, production planning and scheduling, product design and development, and sales, the latter having the chairmanship of the committee, because of their knowing the most about the customer's desires. Results were astounding—misunderstandings seemed to clear up overnight and any contribution to the war effort can be directly traced to this committee method of operation.

So much was thought of the idea that this committee has been kept functioning and it is expected to keep it operating permanently. All special production inquiries go through this committee as well as all new standard product considerations or revisions of the same, including recommendations of every kind from our product development division.

No key man in production can complain any more because of some special item, or think that the sales department is crazy for wanting something finished in blue instead of red, or resist any sudden change in specifications for some standard product. Production approved it while sitting on the committee so, therefore, complaints of this type from production executives down to the foreman have practically ceased to exist. The same is equally true in the sales department. Sales can no longer complain that production refused to manufacture "this or that" item, that die cost is ridiculous, or that production should be making product X with different hardware or lighter gages, or painted pink instead of yellow, etc. Sales, too, were a party to the decision in the first place, so grumblings against our production or development departments are seldom, if ever, heard any more.

Production planning can do a more intelligent job of projecting manufacturing further into the future without fear of the item being dropped or of specifications being changed. They can always check with the committee. The purchasing department knows where to go to get first hand information on whether or not certain raw material specifications are apt to change for the benefit of long-pull commitments. And last, but not least in listing just a few advantages, the field sales force get official information at regular intervals as to why "this or that" can't be changed or why "this or that" has been changed. In the past this group invariably blamed everything on the production division whenever they had any criticism on any of our better than fifteen hundred different items that we catalog.

This recommended method of obtaining co-ordination within a company will automatically improve the customer angle to the same degree that customer relationships are hurt without satisfactory co-ordination within the supplier company. The customer will invariably get what he wants and when he wants it, along with satisfactory explanations when necessary, if engineering, production and sales work as a team and always realize that a profitable operation depends entirely upon the customer's satisfaction.

Management Control of New Design

By L. J. Karmen
Assistant to Executive Vice President
AVCO Manufacturing Corp.
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PRIOR to installation of the present procedure, practice at Crosley radio went something like this. The sales department, anticipating the need for a new line of radios, would get together with the engineering department and management and, in rather broad terms, describe the desired number of models, their characteristics, features, selling prices, etc. The design engineering department would then request and secure an appropriation which would cover their anticipated expenses in connection with the development of such a new line and, upon receiving the necessary approvals, would begin their development work. As each part was designed, but before the set was completed, it would be released from engineering to manufacturing so that the problems of procurement, processing and estimating could be handled as quickly as possible. While there was a certain amount of consultation between engineering and purchasing, and engineering and manufacturing, for all practical purposes, engineering assumed the complete responsibility for the development of a model which would meet the sales department's specifications as to performance, appearance and cost.

This method of handling the development or design engineering is about the same as used in almost all manufacturing companies to a greater or lesser degree. It has one weakness; namely, that it is an inefficient, old-fashioned and costly procedure. Mind you, we have an excellent engineering department at Crosley and, in my opinion, it is second to none in the industry but, when our old method produced as high as 100 engineering changes on two models between the start of development and the end of production, it was obvious that such a system needed overhauling. When I say "over 100 engineering changes on two models", which incidentally differed from each other only in cabinet, the implication obviously is that the engineering department did a bad job. Such is not the case, however, in that the number of engineering changes that could be charged as "engineering errors" was nominal. The bulk of engineering changes were requested by the factory from a processing and assembly standpoint, by purchasing from a procurement standpoint, and last, by sales from a feature or performance standpoint. In addition, there were a number of so-called "clarification changes" which merely added dimensions, etc.

The great number of engineering changes encountered in the production of this particular model served as a red flag to the management of Crosley and we recognized that here was an avenue for improvement.

As funny as it may sound to you or to writers of "How to Manage" or "How to Organize" books, we found that the main weakness in our system was that the engineering department would take the responsibility, and the sole responsibility, for the development of a model with occasional assistance from other departments, but only if requested by the engineering department. This statement, implying that the engineering department should *not* take the responsibility, may sound like heresy to many.

In considering the problem of engineering changes, with respect to the contributions that might be expected from a general committee such as our product manager's group, we soon decided that such a committee is more effective when dealing with the broad planning management aspects of the problems in their respective product fields rather than the specific details involved in such a complex subject as design engineering. We then considered the many alternatives that were open to us in the situation and decided upon a procedure or method which we felt would reduce engineering changes substantially and, in addition, give management factual information upon which to make decisions.

In the product manager's committee the sales department indicates, in writing, the preliminary requirements on a new model. The engineering department then records, after a thorough discussion of the required model, the engineering costs of producing this specific model to the point where it can be played, seen and studied. They also indicate the time that it would require to complete their phase of the work. The works manager next indicates his recommendations from a production standpoint, and finally the patent attorney writes in his blessing, or lack of blessing, with respect to the patent situation on the proposed model. Once the product manager's committee has completed the form and approved it, the program is sold by the product manager to the management committee consisting of the general manager, the general sales manager and the director of engineering. Once approved by the management committee, the form constitutes an automatic appropriation for the development of the specific model.

Management committee members examining a mock-up of a new model Crosley portable radio

During the course of the actual development work, the "breadboard" stage is reached wherein the proposed circuit and components are assembled, as the name indicates, on a breadboard to determine whether or not the proposed circuit design and components will yield the required performance. The next stage is the making up of a chassis pan in the model shop and the mounting of the circuit and components on the chassis so that, at this point, from a radio set standpoint, the design is practically completed and ready for assembly into a mock-up cabinet, or into a cabinet similar to the one proposed.

In both phases of the development work, a group of "foreigners", as far as the engineering department is concerned, are brought in about once a week in order to review, with the engineers, all of the work that has been done on the radio to date. These "foreigners" consist of: (1) The chief industrial

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engineer who is responsible for tooling, processing, and assembly methods as well as plant layout; (2) the radio purchasing agent who, of course, is in charge of the procurement of all raw materials and finished components; (3) the chief inspector, and (4) the general service manager who is responsible for the entire service operation, including repair and replacement in the field and the distribution of parts.

The purchasing group, particularly in difficult procurement times, which lasted from the close of the war to a relatively short time ago, continually pointed up items which, if incorporated in the design, would present a procurement problem. In addition, the procurement people might recommend the substitution of one manufacturer's component over another in order to gain a cost advantage.

The service department representative looks at the design from the standpoint of whether or not it can be easily serviced in the field, and with his experience background on part failures, it is relatively easy to have slight changes incorporated which will make the serviceman's life easier.

The inspection representative, in considering the physical limitations of both the testing equipment available and the ability of his personnel, is vitally interested in the matter of tolerances and performance specifications. As a matter of fact, each individual looks at the proposed design from his own narrow viewpoint, figuratively speaking.

Under this method of co-ordinated and co-operative action by practically all departments involved, we have in effect a statement by all departments that to their knowledge, collectively and individually, the completed model is designed properly. The engineering department still carries the overall responsibility for the development of a new model or product but in effect it is more of a group responsibility. That the procedure outlined has been beneficial is evidenced by the fact that: (1) The number of engineering changes has taken a nose-dive; (2) standardization on parts used by engineering in their design has been accelerated; (3) forecasted production schedules are more closely met; (4) the cost estimates are practically on the nose; (5) quality is controlled inasmuch as the working model is thoroughly tested and approved prior to the start of production; (6) the engineering department has sufficient time in which to do a good design job as the sales department must outline its program sufficiently far in advance in order to have production start at a given time; (7) management has a completely wrapped-up story and all the facts necessary upon which to make a decision, and as a result, financial forecasts are almost on the nose.

Getting Flexibility Into Machinery

By Ned Drucker
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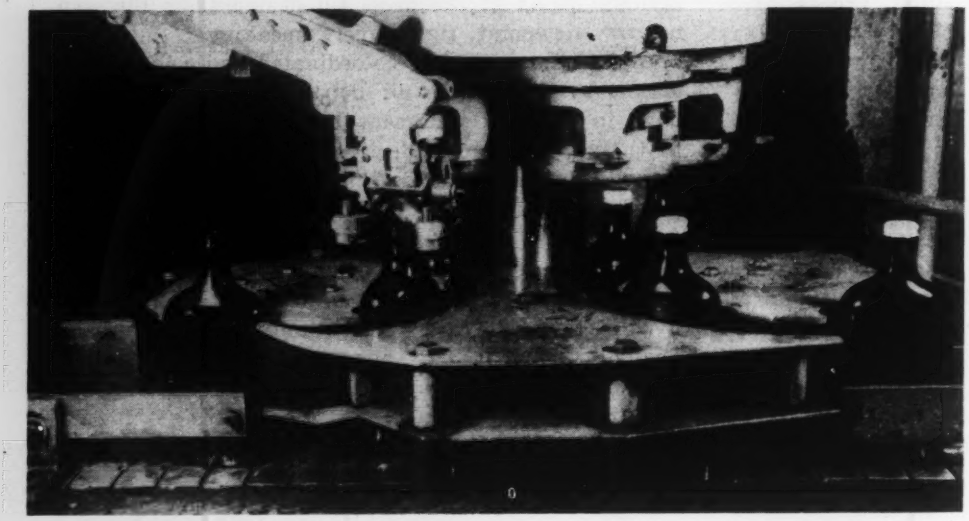
Cincinnati, Ohio

PRINCIPAL difficult in achieving production flexibility lies in the rigidity caused by the greater mechanization, higher speeds, and closer tolerances by which we achieve higher production and better quality. Flexibility, therefore, can only be obtained by establishing specific balances which at each point compensate for what might be termed production inertia. Specific steps, however, can be taken in order to achieve flexibility as exemplified by actual steps taken within our own plants particularly with reference to packaging and assembly operations.

It was decided to achieve the necessary capacity increase as much as possible within the limits of our existing structures, and to utilize a greater proportion of automatic equipment and faster equipment, and where necessary to employ more production units within the same space. In selecting this equipment, we decided to standardize on one make and model of machine for each similar operation. The standard machine was chosen first for speed, second for flexibility, and by that I mean the ability to be changed from one operation to another rapidly and with a minimum number of attachments, and finally for ease of maintenance. Standardization of this type resulted in certain production units having overcapacity for production at the particular time the plans were being made. However, it placed us in a position of being able to handle a full range of sizes on any of our units at a uniform rate. There were, of course, instances where it was not possible for us to completely standardize on one make of unit, either because of our inability to get necessary deliveries or because of the existence within our plants of previously purchased machinery of different makes. Where this problem occurred, we segregated different makes of machines by plants using as a criterion our prewar distribution of business and concurrent variety.

All of our newer units were purchased with automatic feeds and discharges. We synchronized the drives of these units, so that each unit on a production line ran at identical speed. As a result after a piece had entered the first machine it was fed to every other machine without respacing or contact with another package. This development had been used to some extent prior to the war and is similar to the synchronization used in newspaper plants.

The next step was to design "universal" attachments for each machine. In the past it was con-

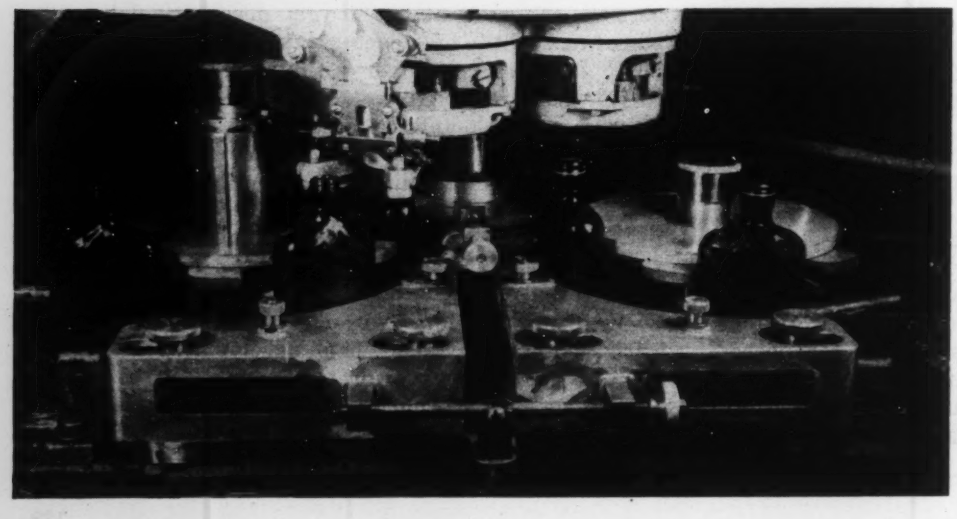


Type of attachments originally furnished with the capping machine which require a different set of attachments for each bottle to be handled in production

sidered necessary to have a special set of attachments for each item. The concept was that in setting up for a particular job it was necessary only for the mechanic to choose the proper attachments and place them on the machine. As a matter of fact, with all fully automatic production lines and with a changing proportion of different items to be shipped, this practice became unwieldy. It necessitated a tremendour number of special attachments, and if the production of a particular item increased to a point where a more than normal number of machines had to be placed in production for that item, special attachments became unavailable for the marginal lines. This quite often required improvised set-ups. An additional problem, caused by the use of special attachments, lay in the time required for their delivery or manufacture. Finally, ease in setup was found to be more of a fallacy than a fact since tolerances in supplies quite often required special adjustments by the setup man not originally provided for.

In achieving so-called universal attachments, the entire range of items to be handled was classified into size groups. For each of these groups we established the maximum and the minimum required for each dimension. We then designed what we consider primary attachments, which need be changed only under unusual circumstances. Each of these primary attachments were constructed with a range of adjustments. For this primary attachment we designed secondary attachments for each classification, which could be changed rapidly. In addition to these secondary attachments we provided a final fine adjustment. As a result many changes now require only thread adjustment and few require more than quick replacements.

The increase in automatic machinery required a comparable increase in setup and maintenance men. We realized that this would require a training program for new men and arranged to classify setup methods already in use. However, when we checked the methods used by our more experienced mechanics we found that no two of them went about the work in exactly the same manner, or checked identical points. We therefore instituted a program of standardization, both in maintenance and setup methods. Manuals were written for each machine clearly outlining the sequence of steps to be followed, check points to be observed, and the tolerances to be allowed at each step. In addition, specific limits have been established throughout all machines so that it is possible for setup men to achieve uniform results.



View of the new universal attachments including adjustable guides and star wheels for the capping machine setup shown above

Superprecision Ball Bearings

By Thomas E. Rounds
Chief Engineer
The Barden Corp.
Danbury, Conn.

Part V—Fitting, Installation and Removal

PROPER fitting of bearings to both the housing and to the shaft is much better understood today than in past years. In order to assure satisfactory bearing life and performance there are a number of definite design principles which must be recognized and kept in mind.

SHAFT AND HOUSING FITTING PRACTICE: To obtain the maximum in performance and service life the fits specified for any particular design must be selected to suit the expected service conditions. For convenience in discussion, typical groups of bearing loading conditions are made as in the following paragraphs.

Light Loads, Low and High Speeds, with Shaft Rotating: For these conditions use close clearance fits on the shaft and in the housing.

Heavy Loads, Low and High Speeds, with Thrust Predominating: With these conditions, press fits may in general be avoided on the shaft and in the housing. However, consideration again must be given the provision of shaft and housing shoulders of adequate area, well aligned and square with the cylindrical seating surfaces.

Heavy Loads, Low and High Speeds, with Radial Load Predominating: Use a light press fit on the shaft and a close clearance fit in the housing. Depending on the magnitude of the press fit used, a free fit bearing may be required. While in certain rare instances a sliding fit may be used where the load revolves with the shaft, it is safer to resort to a press fit to avoid contact corrosion or fretting corrosion between the inner ring bore and the shaft. For extreme unbalance conditions, a tight fit may be necessary in the housing. If this is the case, special considerations will be necessary to avoid end thrust constraint due to temperature variations. Press fits of more than 0.0001-inch must be avoided with preloaded bearings and nonpreloaded bearings with less than 0.0001-inch diametral clearance. Radial preloads may be used at low speeds under conditions of high-grade alignment only where some friction can be tolerated.

Engineering handbooks published by all bearing manufacturers list in tabular form recommended shaft and housing sizes for use with the various sizes and tolerance grades of bearings. These need not be repeated in this article. However, the accompanying examples in TABLE V will illustrate fitting practices used on three typical precision applications.

SELECTIVE ASSEMBLY FITTING PRACTICE: In recent years much progress has been made in the improvement of the resulting mating fits between bearings, shafts and housings. The introduction of improved gaging methods for both bearing parts and their mountings along with the improvement of grinding machinery has made it possible to develop assembly systems with parts pregaged into tolerance groupings. With this procedure, the parts are produced to the total working tolerance allowed (0.00015-inch, 0.00020-inch, 0.00030-inch, etc.) and then carefully measured and sorted into tolerance groupings and subsequently identified by code markings. At time of installation, a selective assembly procedure is used which permits a more accurate resulting fit and avoids certain con-

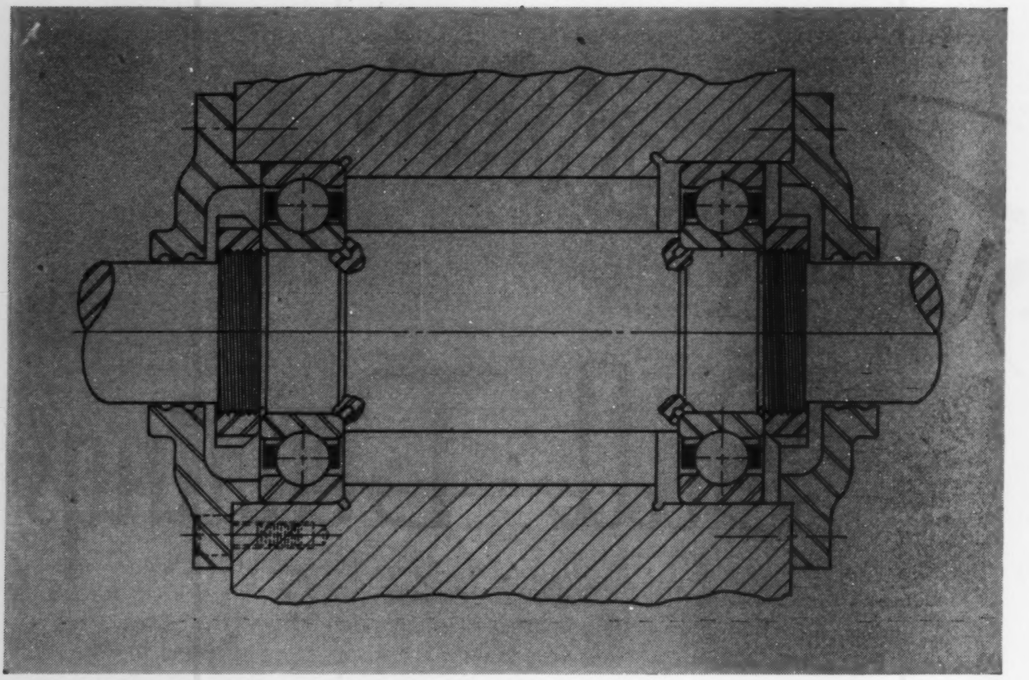


Fig. 33—Housing design bored from each end presents installation and removal difficulties where press fits are necessary

tamination hazards. All too frequently assemblers have made a practice of machining, polishing or lapping parts to suit ball bearings with the result that the ball bearings have suffered from the presence of fine dirt, metallic chips and grit.

One of the standard systems used by several manufacturers is to order bearings with the ABEC-5 tolerance on bore and outside diameter sorted into two groups of 0.0001-inch each at the bearing manufacturer's plant. In doing this, it is incumbent that both bearing and the instrument manufacturer hold errors of taper, out-of-round and bell-mouth to a figure within the selective tolerance group limits. The company with which the writer is associated makes a practice of defining the bore size as the minimum measurable bore and the outside diameter as the maximum measurable outside diameter. Continuous production checks guarantee that variations in bore and outside diameter size on individual bearing parts do not exceed the group tolerance limit of 0.0001-inch on ABEC-5 bearings and 0.000075-inch on ABEC-7 bearings.

With 0.0002-inch tolerances allowed on shafts and bearing bores, obviously a total resultant fit range of 0.0004-inch is possible if no selective assembly is used. By cutting each of these tolerances one-half, a total tolerance range of the fit of 0.0002-inch is possible. Where ABEC-7 tolerances of 0.00015-inch apply on bearing bores and by holding shafts to the same tolerance and further subdividing into groupings of 0.000075-inch each, a resultant fit range of 0.00015-inch is possible. The use of precision gaging methods is mandatory. Air and electric gages are now available which will accurately read to 0.000025-inch or less. In many cases, manufacturers are resorting to precision lapping or honing of shaft and housing seatings to reduce errors of waviness and taper and to assure better seating conditions.

In accompanying TABLE VI is shown the effect of using selective assembly with shafts, bearings and housings preselected into tolerance groupings of one-half the usual range.

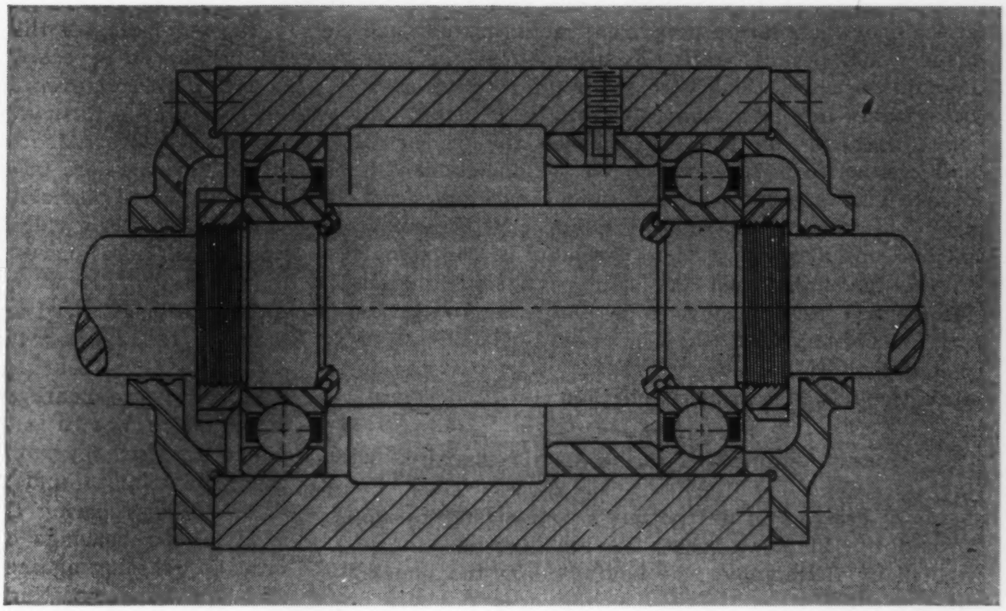
INSTALLATION AND REMOVAL OF BEARINGS: Bearing manufacturers have for many years emphasized very

TABLE V—**Shaft and Housing Nonselective Fitting Practice**
(Inches)

		Shaft Fitting Practice				Housing Fitting Practice			
Application	Bearing Size	Bearing Bore	Mean Fit Desired	Shaft Diameter	Resulting Fit	Bearing Diameter	Mean Fit Desired	Housing Bore	Resulting Fit
Small angular movement, slow speed Loads—Radial 1.5 lb —Thrust 3 lb	No. 34 Deep-groove ABEC-5	0.15750 0.15730	0.0002 loose	0.15730 0.15710	0.0000 to 0.0004 loose	0.62990 0.62970	0.0003 loose	0.63020 0.63000	0.0001 to 0.0005 loose
High-speed spindle, 45,000 rpm Loads—Radial 10 lb —Thrust 25 lb (adjusting spring)	No. 202-H Angular-contact ABEC-7	0.59060 0.59045	Line to line	0.59060 0.59045	0.00015 tight to 0.00015 loose	1.3780 1.3778	0.0002 loose	1.37820 1.37800	0.0000 loose to 0.0004 loose
High-speed gear drive, 22,000 rpm Loads—Radial 210 lb (Very heavy radial load for this size bearing)	No. 203-KT Deep-groove ABEC-5	0.66930 0.66910	0.0002 tight	0.66950 0.66930	0.0000 to 0.0004 tight	1.57480 1.57460	0.0002 loose	1.57510 1.57470	0.0001 tight to 0.0005 loose

In all of the above cases the extremes of resulting fits may be too tight or too loose.

Fig. 34—Through-bored housing design which utilizes a locked collar ring to avoid installation and removal difficulties



strongly those sound practices which will avoid damage to bearings during installation. Certain types of bearings will withstand more abuse than others, but one factor stands out most strongly; cleanliness.

Under no circumstances should precision bearings be installed under ordinary shop conditions. A separate installation room sealed off from the usual shop atmosphere is essential. While air conditioning to control temperature and humidity is desirable in the installation room, of paramount importance is the need for avoiding the hazards of abrasive dirt, dust and metal chips. The room should have a tight finished floor covered with linoleum, and the walls and ceiling should be painted to seal off loose particles. Work benches should be linoleum covered. The entire room should be cleaned daily with a vacuum cleaner. Good housekeeping, orderliness and neatness are all essential.

For cleaning mounting parts such as shafts, housings, collars, etc., provision should be made for solvent spray cleaning. A source of clean, dry compressed air for a spray gun which when used in a hooded compartment connected with an exhaust fan will eliminate vapor hazards.

So far as washing compounds are concerned, only filtered mineral solvents of the equivalent of Stoddard Solvent should be used. Chlorinated solvents are hazardous and should be avoided. For filtering, a funnel with a chemical filter paper cone may be used for the simplest installation, but where large quantities of parts must be cleaned, a separate room with a filtration system for the solvent is desirable. Obviously, fire precautions should be observed and fire extinquishers should be available.

All bearings should remain wrapped until ready for installation. Most bearing manufacturers take unusually good care to make certain that new bearings are clean.

In the design of all mountings, the designer must consider how the bearings and parts will be handled

TABLE VI—Shaft and Housing Selective Fitting Practice

(Inches)

			Shaft Fitting Practice				Housing Fitting Practice			
Application	**Bearing Size**	**Group No.**	**Bearing Bore**	**Fit Desired**	**Shaft Diameter**	**Resulting Fit**	**Bearing Diameter**	**Fit Desired**	**Housing Bore**	**Resulting Fit**
Small angular movement, slow speed	No. 34 Deep-groove ABEC-5	1	0.15750 0.15740	0.0002 loose	0.15730 0.15720	0.0001 to 0.0003 loose	0.62990 0.62980	0.0003 loose	0.63020 0.63010	0.0002 to 0.0004 loose
Loads—Radial 1.5 lb —Thrust 3.0 lb		2	0.15740 0.15730	0.0002 loose	0.15720 0.15710	0.0001 to 0.0003 loose	0.62980 0.62970	0.0003 loose	0.63010 0.63000	0.0002 to 0.0004 loose
High-speed spindle 45,000 rpm	No. 202-H Angular-contact ABEC-7	1	0.59060 0.59053	Line to line	0.59060 0.59053	0.00007 tight to 0.00007 loose	1.37800 1.37790	0.0002 loose	1.37820 1.37810	0.0001 to 0.0003 loose
Loads—Radial 3 lb —Thrust 25 lb (from adjusting spring)		2	0.59052 0.59045	Line to line	0.59052 0.59045	0.00007 tight to 0.00007 loose	1.37790 1.37780	0.0002 loose	1.37810 1.37800	0.0001 to 0.0003 loose
High-speed gear drive, 22,000 rpm	No. 203-KT Deep-groove ABEC-5	1	0.66930 0.66920	0.0002 tight	0.66950 0.66940	0.0001 to 0.0003 tight	1.57480 1.57470	0.0002 loose	1.57510 1.57490	0.0001 to 0.0004 loose
Loads—Radial 200 lb —Thrust zero (very heavy radial load for this size bearing)		2	0.66920 0.66910	0.0002 tight	0.66940 0.66930	0.0001 to 0.0003 tight	1.57470 1.57460	0.0002 loose	1.57490 1.57470	0.0000 to 0.0003 loose

In all of the above cases, the extremes of the resulting fits avoid excessive tightness or looseness.

at time of installation. An ideal mounting arrangement would permit, first, the assembly of the bearings on the shaft along with all of the rotating members which are later concealed in the housing. All shaft seatings can then be checked for proper fit and contact of associated parts. Spindles can be checked for straightness and runout and any necessary corrections for shaft bending can be accomplished in full view prior to assembly of the spindle in the housing. Then the spindle or shaft can be inserted in the housing, caps and slingers can be applied and any final checking operations can be completed with full knowledge that step-by-step the installation has been properly checked.

Proper Assembly Conditions a Necessity

Many designs do not permit a logical step-by-step procedure. In many cases, the bearings must be installed by fitting over the shaft and in the housing at the same time. If the bearing does not slip or press into place readily, it may then be necessary to dismount the installation more or less completely and begin over again. If there is no way to get at the bearing and pull it off properly, frequently the hammer is resorted to and shock forces are applied which may brinnell, or ball dent, the raceways.

If press fits are required for the inner rings on the shaft, the condition shown in *Fig.* 33 will present installation and removal difficulties. Obviously, it will be difficult to mount the shaft and avoid applying some of the press fitting pressure through the balls of the left-hand bearing, unless care is used, together with a mounting sleeve.

While the right-hand bearing, may, in most cases be mounted against its shaft shoulder before the shaft and bearing is inserted into the housing, the left-hand bearing must be pressed or driven on the shaft and in the housing at the same time. Frequently, the outer ring of the bearing may not quite enter the housing bore easily which may mean that the mounting forces, even if exerted on the inner ring, are transmitted through the balls and result in damage to the races. Also the outer ring may be wedged in the housing bore in a cocked position.

In *Fig.* 33, to dismount the bearings for any reason, one bearing will certainly be ball dented if an inner ring press fit is used. However, if the mountings shown in *Fig.* 34 were used, the housing shoulder collar can be released and the shaft assembly can be removed readily and taken to the bench where by pressing off the bearings against the inner rings no damage to the bearings will result. Another type of mounting, shown in *Fig.* 35, often termed as "opposed mounting" permits the use of the most foolproof installation and removal methods.

By through boring the housing, as in *Fig.* 34 or *Fig.* 35, the bearings can be installed on the shaft first, by pressing against the inner rings of the bearings and later inserting the shaft and bearings into the housings (with the usual clearance fit) without damage.

Summarizing, the more readily that bearings can be mounted and dismounted by straightforward means, the less trouble will be encountered in the field. Ball dented bearings will run noisy and not give the proper performance. The slight additional cost of more careful attention to original bearing mounting design is often far less than the cost of following field service troubles and establishing the real cause and subsequently correcting ball bearing mounting and replacement troubles.

The final article in this comprehensive series on superprecision ball bearings will appear in the May issue, the forthcoming April issue being specially devoted to machine drives and controls. The concluding article, Part VI, will cover bearing lubrication, lubricants and systems.

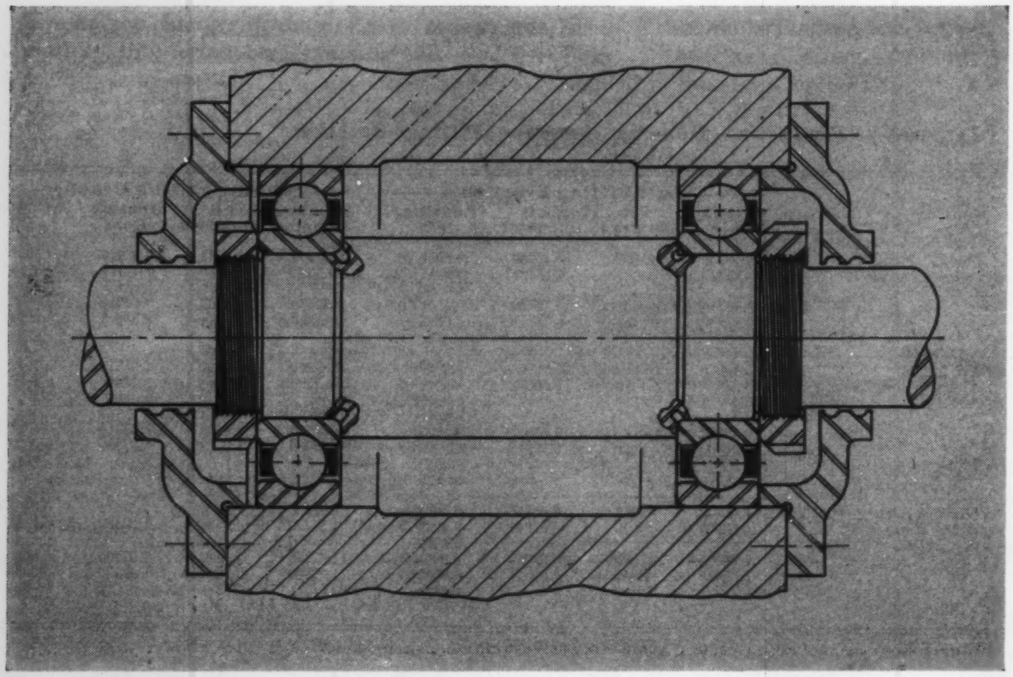


Fig. 35—Through-bored housing design with opposed mounting of the bearings permits almost foolproof assembly and removal

Design for

MASS PRODUCTION

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TO DETERMINE suitability of a design for a specific production quantity, a cost criteria is proposed in this abstract of a paper presented at the recent SAE Annual Meeting in Detroit. Although based on aircraft production, principles set forth as a guide for realistic production design are applicable to any industry even though quantities may differ

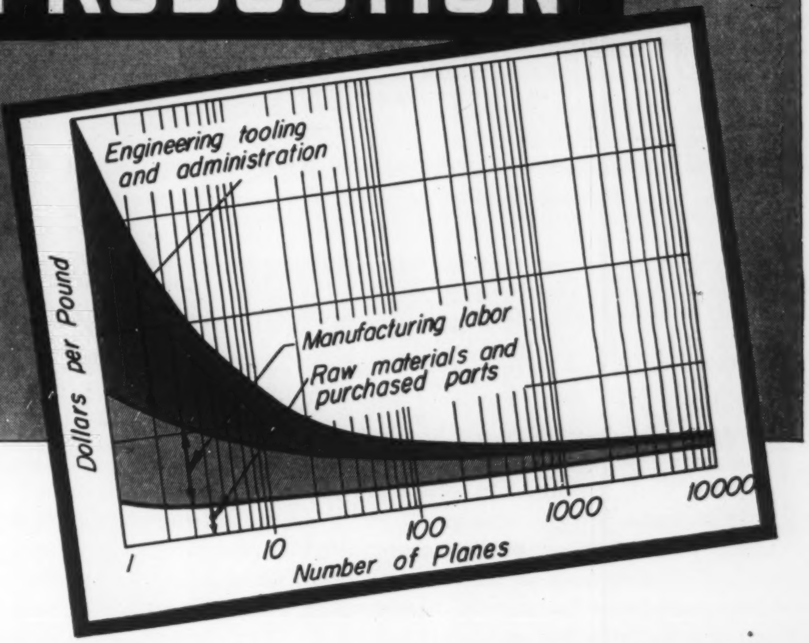


Fig. 1—Cost distribution in dollars per pound compared with number of airplanes produced

MASS production cannot be defined except in relative terms based upon the folklore of an industry. To the automotive industry it may imply a million units, elaborate tooling, conveyor assembly lines and the like. To the aircraft industry it may mean several hundred units, a wartime hangover and a manufacturer's desire to buy into the market or a willingness to gamble corporate funds to defend a position in a competitive market.

To determine if a design is the most suitable for the quantity, a yardstick or criteria is needed. Cost is the best measure of effort since man-hours, material and time can be converted into dollars. Factors that control cost are:

1. Design
2. Quantity
3. Reservoir of skill and experience
4. Adaptability of an organization to new problems
5. Company management and their understanding of these relationships so that an effective control can be exercised.

Design affects the cost of an airplane in two ways:

1. Direct: It establishes the minimum or "basic" cost which is so important in high quantities
2. Indirect: It may cause manufacturing disturbances due to a departure from past practice. In moderate quantities, this cost may be many times greater than the basic cost.

Looking carefully at the distribution of costs, we can see where to place design efforts. Several methods of breaking down the cost might be employed, but grouping them in the following three categories results in some fairly clear trends.

1. Raw material and purchase parts
2. Direct and indirect (burden) shop labor
3. Engineering, tooling and administrative costs.

Item 3 is largely an initial cost that must be amortized over the production quantity plus the normal maintenance and charges.

How the dollar per pound costs drop with increasing quantity and the variation of each of these three groups are shown in *Fig.* 1. While vertical ordinates are not shown, this scale is linear (semilog). The

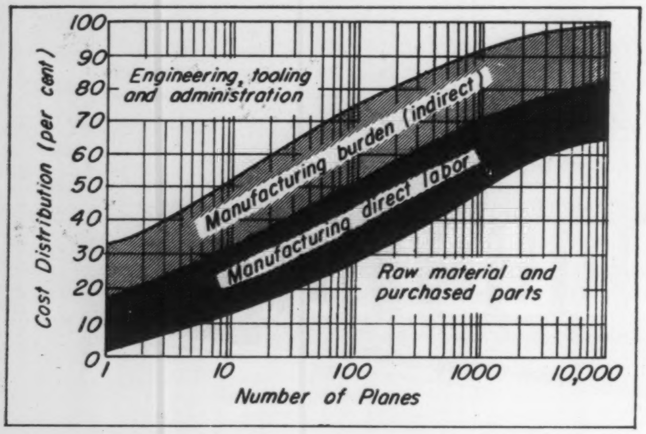


Fig. 2—Percentage of cost distribution in relation to airplane quantity of production

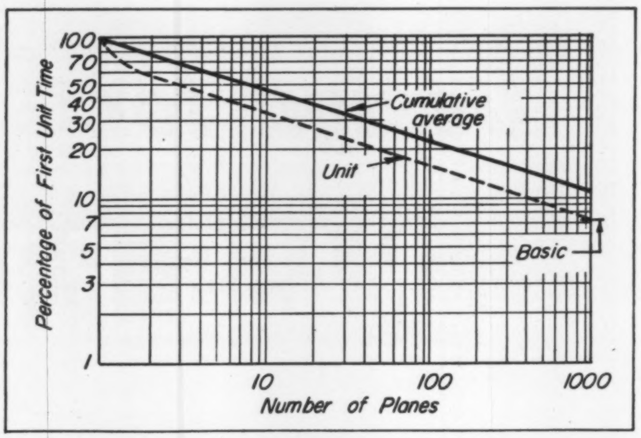


Fig. 3—Eighty per cent learning curve for direct labor as a percentage of the first unit time (log-log plot)

same data plotted on a percentage distribution instead of dollar per pound, show the relative importance of each group for any quantity, *Fig* 2.

From these two graphs several things are obvious. For prototypes and extremely small quantities, raw material and purchased parts costs are unimportant. The important costs are manufacturing labor, engineering and tooling. In other words, to keep the overall costs within reason, it must be an off-the-shelf job, using as much accumulated engineering, manufacturing techniques and know-how as possible.

As quantities increase to 10,000 units, the order of importance changes materially, *Fig.* 2. Raw material and purchased parts costs now take on real significance while the importance of engineering and tooling has shrunk to insignificant proportions.

It is interesting to see how the labor cost retains a rather consistent importance. While the ratio of indirect (or burden) to direct labor may vary from 70 to 130 per cent of the direct labor in different organizations and accounting practices, it may be split evenly in an effort to determine more about the direct shop labor hours and the influence of design.

These direct shop labor hours are most frequently considered in design decisions. For years the aircraft manufacturer has used the so-called "learning curve" for predicting costs (direct labor man-hours). The data which was originally collected in an empirical form has been verified by experience and the equation $Y = K/X^n$ was fitted to the data. Different firms, and even the same firm, for different models, may use different rates of improvement. It is not particularly important to this discussion which rate of improvement is used, but several assumptions will be made for convenience.

An 80 per cent curve fits rather well the wartime industry average for complete airframes. This means that for each block of airplanes the average cost is 80 per cent of the previous like quantity. The 200th unit will be 80 per cent of the 100th unit. When plotted on log-log paper, a straight line is obtained for the cumulative average time and the unit time is practically parallel after about twenty units, *Fig.* 3.

When plotted on semilog paper these same data appear as shown in *Fig.* 4. Many production people feel this trend will continue indefinitely, while others think the unit curve will level off at some value, say one thousand units. Wartime experience tended to show the continued improvement. However, in most instances there was continued improvement in tooling and methods that continually lowered the basic or elemental time. In some instances simple assemblies have leveled off at one hundred to five hundred units where the tooling or methods were unchanged.

For a happy compromise that won't be too far amiss, let us assume that the unit time will level off at one thousand units or basic time. This basic time should equal the summations of all of the work elements.

Basic Work Remains the Same

There is one very important conclusion that may be drawn from learning curves. The actual amount of basic or elemental work is no different on the one thousandth unit than on the first unit. There are the same number of parts, the same number of rivets and still the prototype or first unit costs 13.6 times as many man-hours as the one thousandth unit.

If one thousand units are built, the cumulative average cost is $147\frac{1}{4}$ per cent of the basic time. In other words, $47\frac{1}{2}$ per cent more man-hours were spent than if it had not been necessary to learn how to do the job. If only 100 units are built, which is quite a few today, the cumulative average cost is 309 per cent of the basic time.

Since the basic or elemental time is such a small part of the total actual time, it is only natural to ask "what is this unaccountable or lost time?" as shown by the shaded area in *Fig.* 5. The basic time is arbitrarily increased at the start to allow for gradual completion of tooling.

We can't blame all of this time on the assembler bucking rivets. It is "learning" time by intermediate management levels. It represents the progressive solution of production and the correction of engineering and tooling errors, as well as the elimination of parts shortages, bad temporary tools, and unwise sequences of operations. It is also having the right number of men on the line, employing good

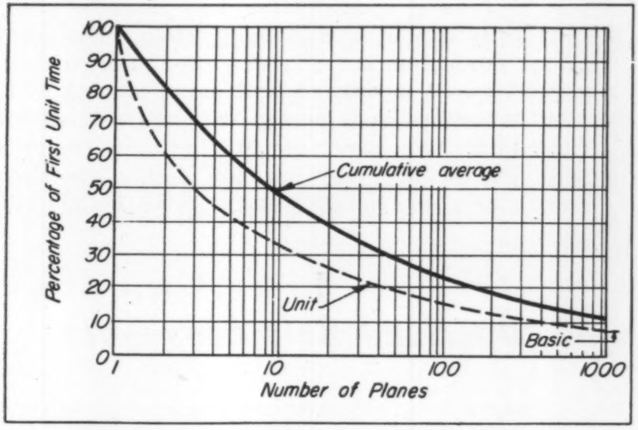


Fig. 4—Eighty per cent learning curve for direct labor as a percentage of the first unit time (semilog plot)

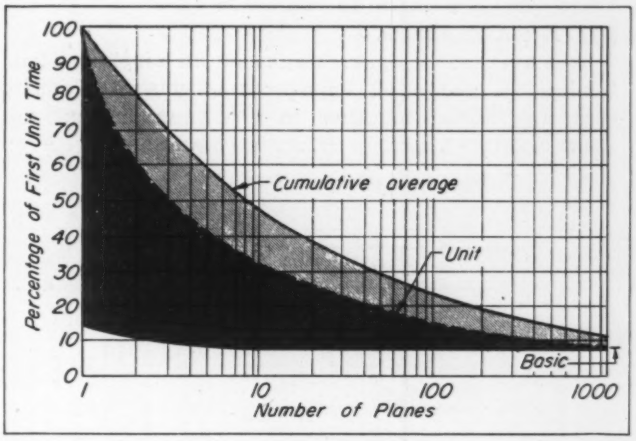


Fig. 5—Lost time due to learning factor shown in relation to basic time

planning and supervision, and the minimizing of delays due to inspection, salvage and the like.

These are the conditions to which we must design when quantities are moderate. If we make design decisions on differences in basic time or time study elements and ignore the learning or disturbance factors, we completely miss the boat. For all but prototype construction, assembly and installation hours run three to four times the fabrication hours. The problem, therefore, is not one of designing parts that are easy to make but rather designing a structure that is easy to assemble.

Generally we can afford to spend a little more for accurate details of fabricated parts and thereby save many times over in assembly economies. An improvement in the dimensional integrity of the airframe structure pays off in the subsequent installations, since less time will be spent in bumping to fit and trimming to suit. These unscheduled operations greatly affect the time reduction curve.

A much argued question is the relative importance of the airframe structure and the equipment installation. Study of several models reveal a trend as shown in *Fig.* 6. Generally speaking we are safe in assuming them to be of nearly equal importance for higher quantities. We should, therefore, spend as much production design effort on installations as on airframe structure.

Design Producibility

As an outgrowth of recent industrial mobilization planning, considerable concern has been placed upon "design producibility". It is a natural development in that the services recognized the need for designs that can be rapidly and efficiently produced.

With so much interest, it is well to determine what design producibility is. "Producibility" is in reality the measure of compatibility of the production problems with the facilities and know-how of an organization. Therefore design producibility must be that quality in design that takes these factors into account. It is more than an appropriate production breakdown. It is design that is cognizant of the production problems. This must be co-ordinated with manufacturing in time to have adequately developed facilities and techniques available, so that no manufacturing disturbances develop.

The article "Design Producibility Serves the Industry" by Jones and Harrison which appeared in August-September 1948 issue of *Aero Digest* covers the general principles in complete detail. This article reflects industry agreement with the A.I.A. subcommittee on design producibility. The most important principles are:

1. General configuration should consist of a minimum number of major structures that employ simple shapes, i.e., constant sections, single vs. double curvature, etc.
2. Major breakdown should provide for assembly accessibility, complete installation of systems in subassemblies, and simple joints between subassemblies
3. Structure and equipment should be designed for simplicity, accessibility and minimum number of manufacturing operations, with takeup provisions for manufacturing variations.

These are all points to simplify and reduce the magnitude of tooling and manufacturing problems. The principles are basically sound but there are times when it is necessary to violate them in the interests of functional or tactical performance.

Rather than elaborate further on these principles, several problems that usually do not receive their just share of attention will be discussed. This is probably because we don't understand them fully and fail to recognize how they actually affect such a major part of our design and manufacturing problem.

The airframe industry is in a state of transition comparable to the change from welded steel tube fuselages to all metal construction. The turbojet power plants are changing the configuration of the airplane and we have yet to reach standard configurations that characterize the conformity of present day transports. Aluminum alloy 24S is being replaced by higher strength 75S and stainless steel where the temperatures are too high for aluminum alloy.

The thin, high-speed, swept wings are tending to rule out the conventional skin stringer type of construction in favor of heavy milled plate. All of these changes tend to introduce new design and production problems.

The average designer thinks of an airplane structure as a group of important structural elements that are joined together in any manner that will show positive margins in the stress analysis. From a production viewpoint, the designer should think of the same structure as a group of insignificant structural elements and look at the all-important method of joining, since assembly costs are usually at least 75 per cent of the direct labor. It is the attachments that may make the assembly vulnerable to unscheduled operations, or lost time.

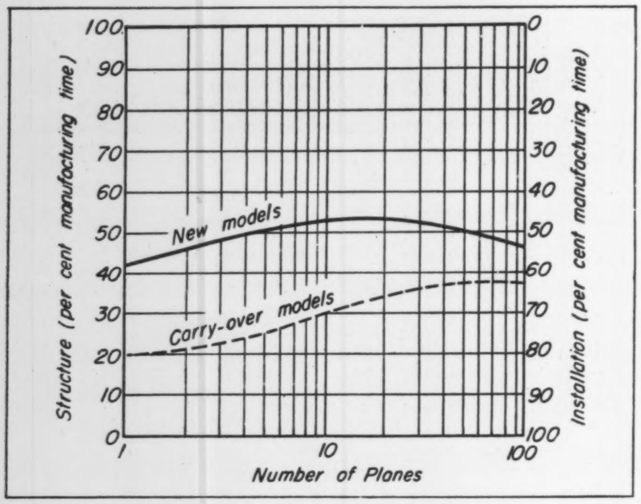


Fig. 6—Percentage of direct manufacturing time for structure and installations in relation to airplane quantity

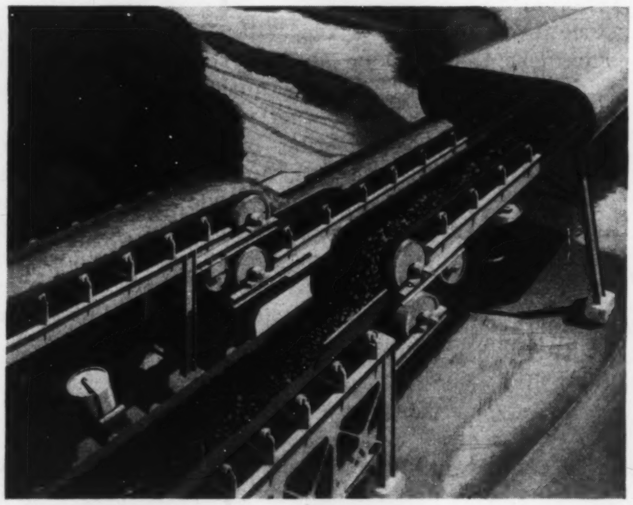
The following principles will, I believe, help the designer achieve producibility through design. We must:

1. Have the right design point of view and design within the limitations of the manufacturing setup that will produce the product. Once management has established a projected quantity, design cost decisions should be rendered upon the economic considerations involved for that quantity, tempered by vulnerability to change
2. Establish an intelligent production breakdown consistent with the quantity. The importance of complete installations that can be checked out and inspected within the structural subassemblies cannot be over-emphasized
3. Design within the limitations of the material and equipment. We must employ "sure-fire" design practices
4. Design structures and installations that are based on an understanding of the normal manufacturing variations rather than wishful thinking
5. Adopt a disciplined point of view with respect to making use of established and proved designs, further refined if necessary, rather than completely redesigning for each new model
6. Explain and preplan major changes that are forced because of competition.

Engineering personnel are in a unique position in that they are first able to recognize the influence a design will have upon tooling and manufacturing. They rightly are in a steering position. Designing for mass production is far from a cut-and-dried slide-rule problem. It is rather a problem of staying within our limitations and in step with the rest of the organization. We must at all times be basically "right" and employ only sure-fire design practices. An error or a bad miss is costly in both time and money.

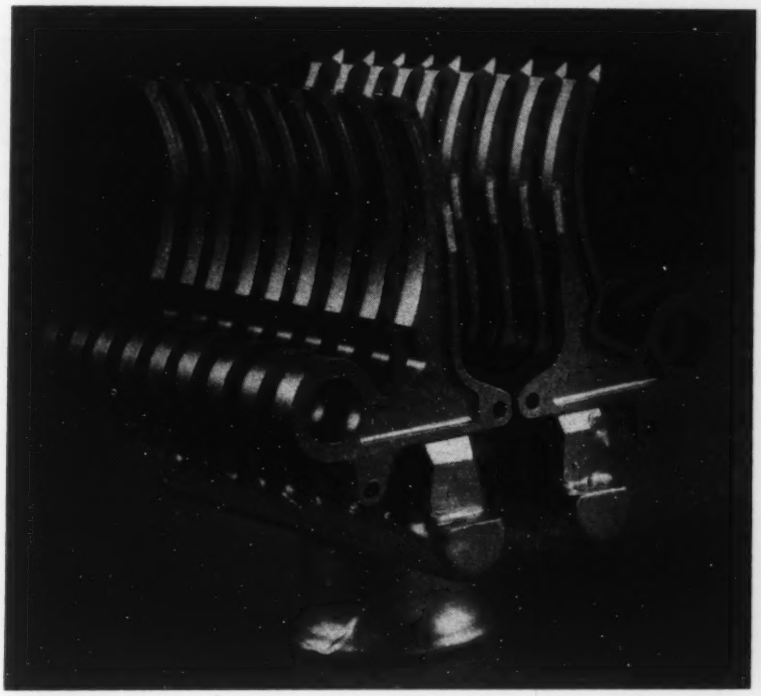
Overland Belt Conveyor

Two-way rubber belt conveyor system extending a distance of 103 miles from Lorain on Lake Erie to a terminal on the Ohio River near East Liverpool is planned for transporting bulk cargoes such as northbound coal and southbound iron ore and limestone. Estimated by Riverlake Belt Conveyor Lines Inc. to save from 20 to 45 million dollars annually in freight charges, the main line of the 210 million dollar conveyor will consist of 172 belts or flights, some more than a mile long. The system of idler pulleys used in doubling back each flight, so that the same surface of the belt carries the load in both directions, was discussed in the October 1946 issue of MACHINE DESIGN.



Coal will move northward from the river on the 72-inch belt of the main line at 600 feet per minute or 3400 tons per hour. Southbound capacity at the same speed will be 5400 tons per hour of the heavier ore. From Salem, where a 42-inch branch line will service Youngstown, to Lorain the belt size is reduced to 60 inches. Another 42-inch branch line connects with Cleveland. Enclosed in an 18-ft wide gallery and elevated 22 feet above ground level, the proposed system will offer all-weather, continuous, low-cost transportation service to the Great Lakes and Ohio River valley areas. Belting engineers from the Goodyear Tire and Rubber Co. and Link Belt Co. have worked with the Riverlake Belt Conveyor Lines Inc. on the engineering phases of the project.

Investment Casting



. . . case study indicates how advantage of process may be utilized

By R. B. Gordon

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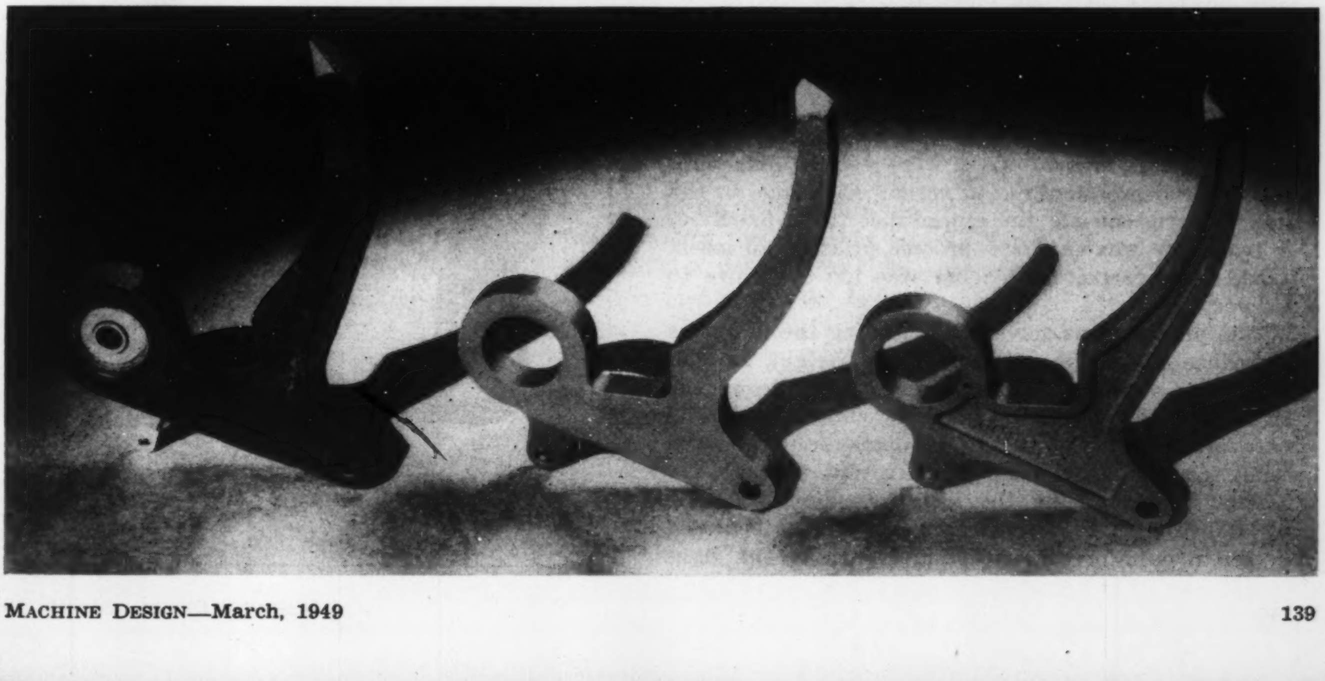
Fig. 1—Above—Cluster of investment-cast levers. Eighteen units are cast in each mold assembly, reducing cost 35 per cent over previous production method

AS WITH most new processes, design engineers should be familiar with the advantages and disadvantages of investment casting. When a part having attractive possibilities is discovered, before specification of investment casting design and metallurgical considerations should be investigated thoroughly.

Development of precision casting of a switchgear

Fig 2—Below—Evolution of lever from former design at left to final redesign at right. Intermediate design in center was modified to eliminate shrinkage depressions on flat sides and unfavorable ratio of length to diameter in small hole resulting in design shown at right



lever on a standard Westinghouse network breaker typifies the problems encountered and the successful solutions obtained. A cluster of these levers as finally developed is shown in *Fig.* 1 before removal of sprue and gates.

This part was originally made by sawing and filing to shape from 5/16-inch thick Nitralloy plate. Several milling and drilling operations were performed on the part and a small spring stud was assembled by means of a drilled and tapped hole. After machining, the part was given a nitriding heat treatment to produce a corrosion and wear resistant surface. The original machined part is shown at the left of *Fig.* 2.

Eliminates Heat Treatment

The first precision cast samples were produced with a shape as shown in the center of *Fig.* 2. The only change made over the previous machined part was the casting of the spring stud as an integral part, eliminating a drilling, tapping and assembly operation. Since the two holes in the piece had very close tolerances, it was impractical to cast to size. Hence, the holes were cast slightly undersize and finished by a reaming operation. This required that the parts be supplied in an alloy and condition that was machinable. The initial samples were cast in 12 per cent chromium stainless steel (Type 410) and had a hardness of about 35 Rockwell C. Shop tests proved that the material was machinable at this hardness level. Furthermore, life tests of the precision-cast levers indicated that strength and wear resistance were adequate. Hence, it was possible to eliminate the heat treatment operation previously used. Nevertheless, nitriding tests were conducted which showed that a hard nitrided case could be produced on the 12 per cent chromium steel, if desired.

Defects Necessitate Redesign

Incidentally, this substitution eliminated a production bottleneck that had resulted from a shortage of Nitralloy plate. After the production of several hundred pieces, it became evident that a substantial number were being scrapped from surface defects occurring at two places on the part, both of which could be remedied by slight design changes. First, the flat nonfunctional sides were coming out with a concave depression due to normal shrinkage in the wax pattern, causing the appearance to be impaired. A two-stage wax injection process utilizing an insert would have corrected this but was too expensive to consider.

This problem was solved by recessing the flat sides to reduce the section thickness and weight without sacrificing strength. Second, the small hole on the lever was causing investment difficulty due to its unfavorable ratio of length to diameter. This was easily corrected by cutting out a slot through the middle, thus reducing the length to diameter ratio by a factor of 3. These changes were incorporated in the revised precision casting shown at the right in *Fig.* 2. Production of castings with this design has proved satisfactory in all respects. These levers are cast eighteen to a mold in an assembly as shown in *Fig.* 1.

Advantages resulting from the adoption of the investment casting process for this lever may be summarized as follows:

1. Piece cost reduced by 35 per cent
2. Spring stud cast integral with lever
3. Production scheduling improved due to reduction in number of manufacturing steps and elimination of material procurement bottleneck
4. Heat treatment eliminated
5. Corrosion resistance improved
6. Surface appearance improved.

These savings were possible despite the fact that the part had been in production for some time, hence a variety of tools and fixtures were already in existence. Obviously, further savings, in tool cost, are possible if investment casting is adopted on new parts in the design stage. Total cost for a precision pattern and a precision mold for the lever amounted to $200.

This example is typical of many similar problems which have been tackled and solved by precision casting techniques. It is believed that the process can break many complex production bottlenecks and that it offers particular advantages in those cases where an intricate part must be manufactured from a material of high hardness. Tooling is both rapid and flexible as well as surprisingly inexpensive for this process of production by the lost-wax investment casting method.

"SECTION MODULUS . . . TENSILE STRENGTH . . . FACTOR OF SAFETY . . . CENTRIFUGAL FORCE . . . CENTER OF GRAVITY . . . CO-EFFICIENT OF FRICTION . . . . SOMETIMES I WISH I'D MARRIED A FOREIGNER!"

MARCH, 1949

MACHINE DESIGN
A PENTON PUBLICATION

Sure-Fire Design Practices

DISCUSSING O. A. Wheelon's SAE paper, which is abstracted elsewhere in this issue, an engineer from a rival aircraft manufacturer challenged the author's recommendation to employ only "sure-fire" design practices. Such restriction, he contended, may hamper progress. The author retorted by pointing out that a good designer likes to express his individuality in his design. Given a free hand he could play hob with production, hence must be disciplined.

Such differences in viewpoints are familiar enough but at first glance it may seem surprising to find them in today's aircraft industry, whose designers are acknowledged leaders in engineering progress. How successfully they have maintained the delicate balance between conservative design which keeps production flowing smoothly and radical design which sets new performance standards is proved by their record.

Further light was shed on this point by Larry Bell in a recent talk. Discussing the Bell XS-1, which has exceeded the speed of sound "by several hundred miles per hour," he explained that the plane's designers went all out for ruggedness to withstand the unknown buffeting forces in the transonic range. Thus, where conventional planes employ sheet metal the XS-1 uses heavy plate. Despite the resulting weight handicap the machine adequately met performance expectations, and no engineering changes were necessary in the course of the development. Apparently the engineers knew when to stop being conservative and when to become radical.

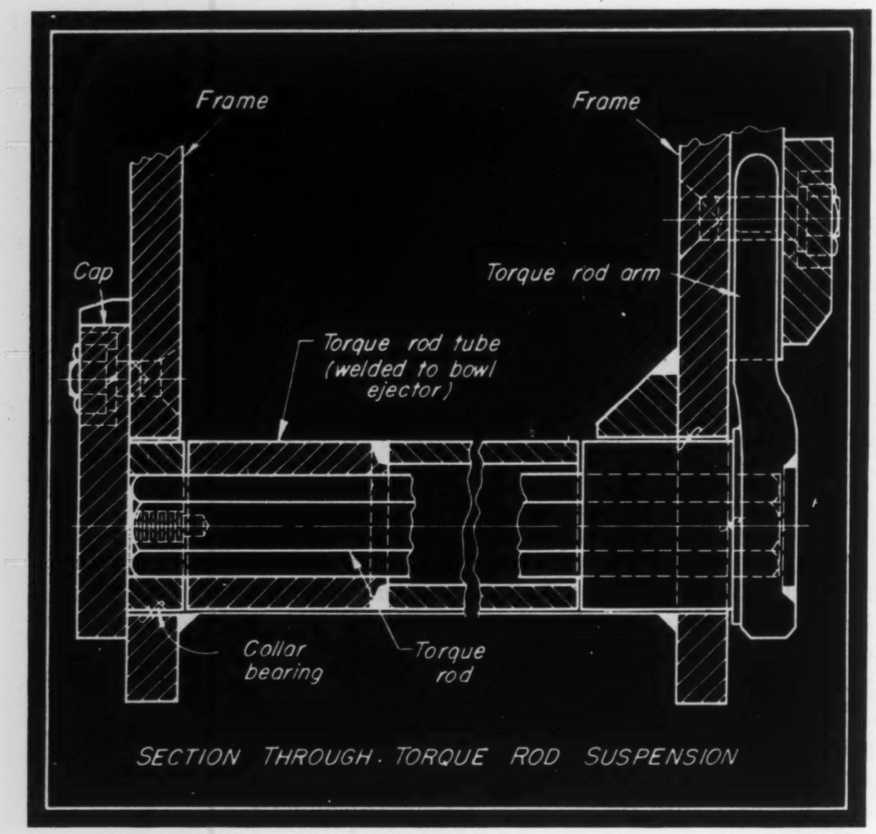
In the more prosaic but no less vital day-to-day problems of other designers the sure-fire technique must continue to be a guiding principle. However, to restrict design to sure-fire practice for a particular organization, industry or type of machine is to stay in a rut. How other engineers are solving their problems by improved design practices, materials, processing methods, etc., therefore must be a major concern of every designer. It is conceivable, for instance, that the designers of the XS-1 could have taken a leaf out of the notebook of the icebreaker designer.

By presenting in concise form the ideas, design techniques and practices of leading authorities, MACHINE DESIGN will continue to do its part in promoting the infiltration of sure-fire design practices between the various branches of the machinery-manufacturing field.

Colin Carmichael

EDITOR

DESIGNS OF THE


Frame
Frame
Cap
Torque rod arm
Torque rod tube (welded to bowl ejector)
Collar bearing
Torque rod
SECTION THROUGH TORQUE ROD SUSPENSION

Torsion Scraper Ejector

RETURN of the scraper bowl ejector after dumping is materially assisted by the torque rod suspension used in the scraper in the photograph below. As shown in the drawing, left, the right end of a hexagonally shaped rod is secured to a torque rod arm and short length of tube having a round outer diameter and hexagonal inner diameter to fit the rod. The left end of the rod fits in a collar which is set loosely in the bowl frame and serves as a bearing for the left end of the torque rod. A tube, the left end of which has a hexagonal bore to engage the torque rod, is welded to the bowl ejector and encloses the entire length of the rod. As the curved bowl ejector is raised by the cable to the position shown in the photograph, the torque rod tube turns, turning the left end of the torque rod where it is engaged by

MONTH

the tube. Right end of the torque rod is held stationary by the arm coming in contact with a flange welded on the frame, thus creating a twist in the free middle portion of the rod. Potential energy set up in this way causes the torque rod to return the bowl back to normal position when power on the bowl ejector cable is released.

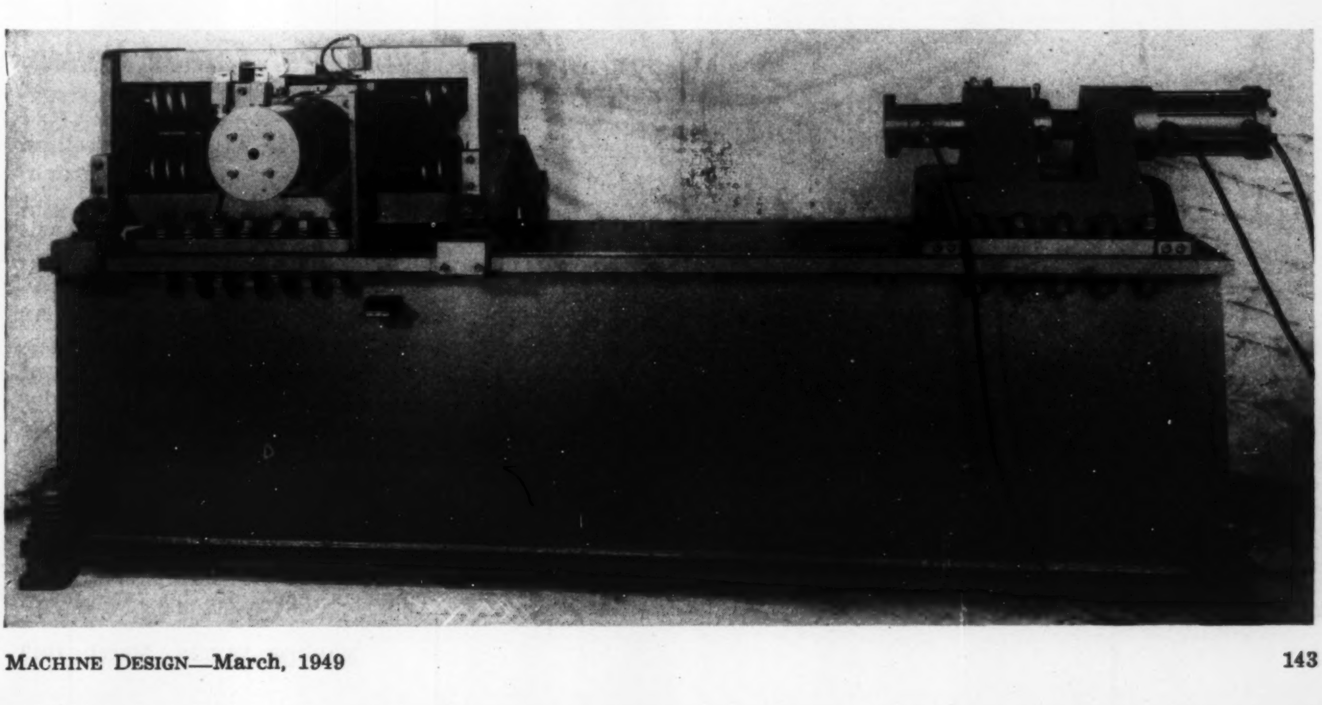
Normal "no twist" position for the torque rod is 12 degrees above full lowered position, resulting in a downward twist in the rod when bowl ejector is in the loading position. This reverse twist helps to break the load loose from the bowl at the start of the dump, when the greatest amount of power is required, and therefore decreases the load on the cable line. Travel of the torque rod is from minus 12 to plus 44 degrees, assuring positive bowl ejector return without imposing damaging twists in the torque rod. Manufacturer: Bucyrus-Erie Co., South Milwaukee, Wis.

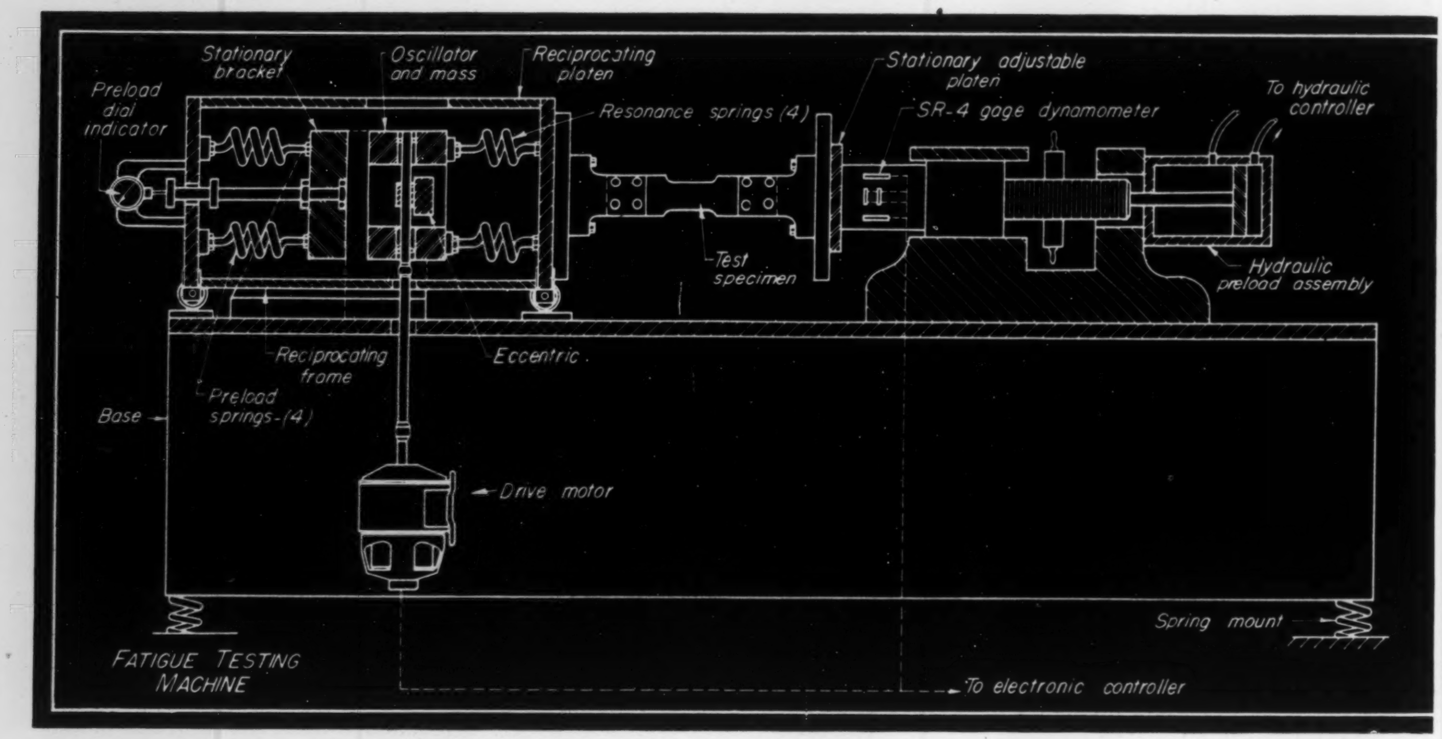
Fatigue Testing Machine

USING the resonance of the front platen assembly to magnify applied loads, the fatigue testing machine, below, will superimpose an alternating load over an average preload in tension, compression, bending or torsion. Alternating forces of 10,000 lb can be combined with a static preload, in either direction, to give a total force capacity in one direction of 20,000 lb. The alternating force is produced by an eccentric mass rotating on a vertical shaft and driven by a direct-current, variable-speed motor. The longitudinal component of centrifugal force of the eccentric mass is transmitted through its housing to four resonance springs, as shown in the drawing top next page. Only about 20 per cent of the maximum alternating force is produced by the eccentric mass, magnification being obtained by working near resonance of the system.

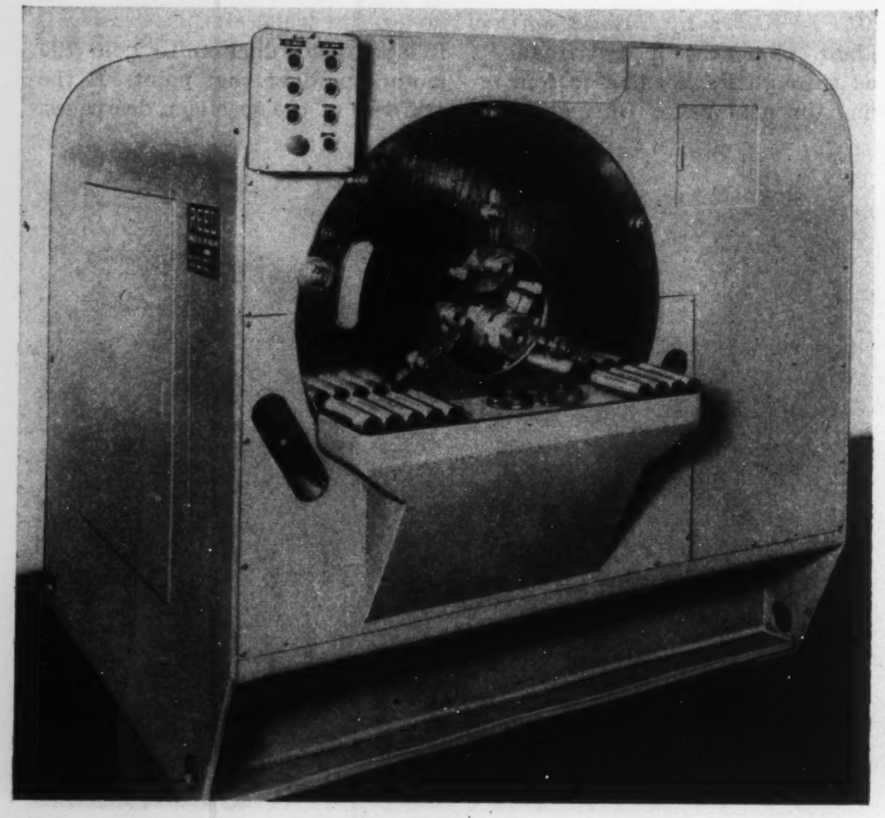
All lateral components of the horizontal vibratory force (at right angles to the springs) is absorbed by a flex-plate guide attached to the base of the machine, and prevents the oscillator from moving sideways. The reciprocating load is transmitted from the resonance spring and front platen assembly through the specimen and to the dynamometer, a tubular member with a series of SR-4 strain gages cemented on its surface. These gages are connected to electronic amplifiers and the motor speed controlling equipment.

In operation, the desired alternating load is set on a load-indicating and control dial and the motor speeds up the eccentric until the magnified centrifugal force produces the load in the dynamometer for which it has been set. Relays then function to hold the motor speed at that point. If the stiffness of the specimen decreases,



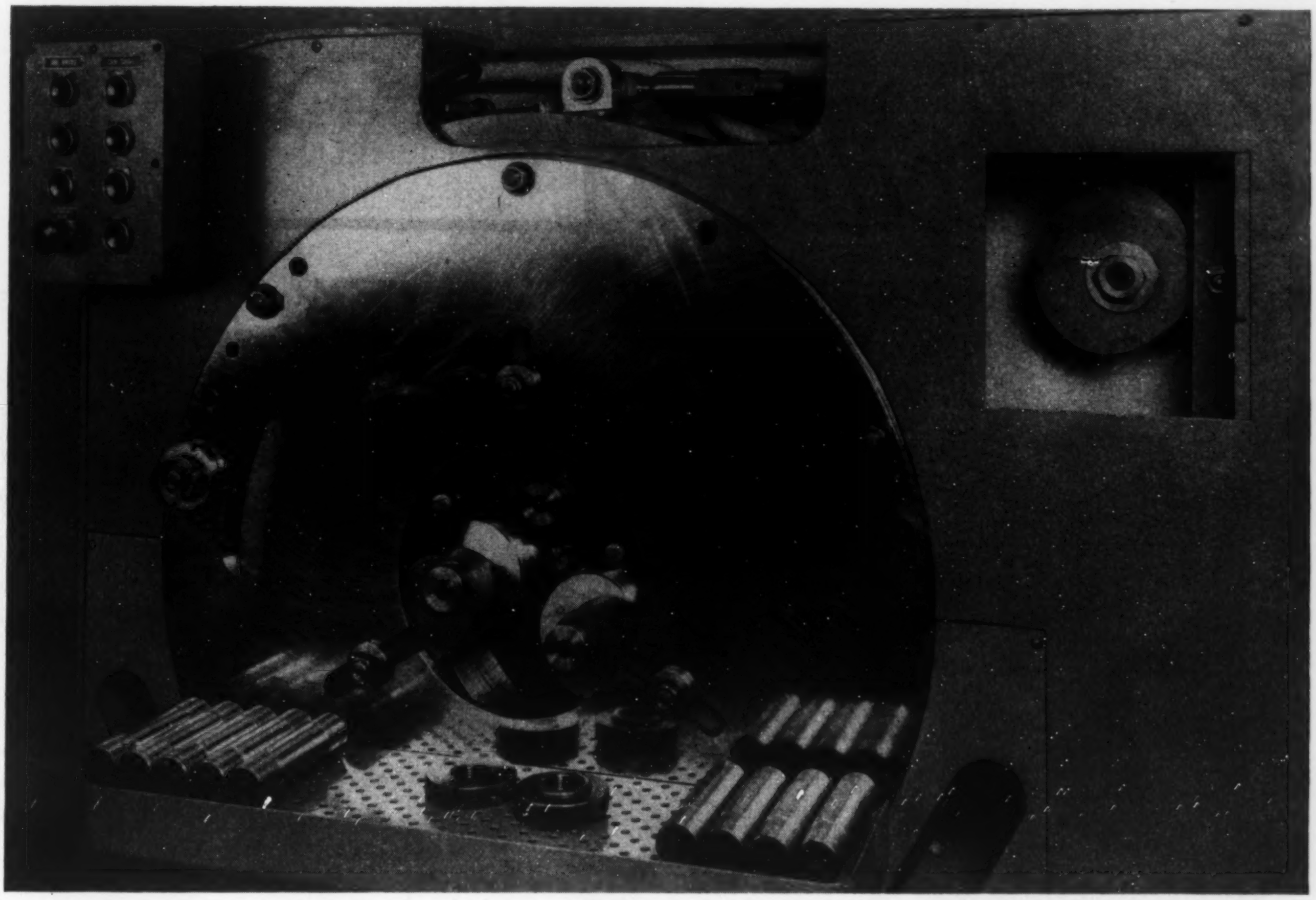

Stationary bracket
Oscillator and mass
Reciprocating platen
Stationary adjustable platen
Preload dial indicator
Resonance springs (4)
SR-4 gage dynamometer
To hydraulic controller
Test specimen
Hydraulic preload assembly
Reciprocating frame
Eccentric
Preload springs (4)
Base
Drive motor
Spring mount
FATIGUE TESTING MACHINE
To electronic controller

relays operate to increase the speed of the motor to produce the preset unbalanced force, keeping the vibratory force constant without regard to the amplitude of vibration. A ½-inch maximum double amplitude of the reciprocating platen permits testing relatively flexible specimens. A double-acting hydraulic cylinder located on the fixed-platen end of the machine is used to set any desired preload on the specimen under test. Failure of the specimen automatically stops the drive motor, a cycle counter indicating the number of cycles to motor cut-off. Since the applied force is constant even with elongation of the specimen, partial failure increases the stress in the remaining section and therefore accelerates complete fracture. Spring mountings on the machine permit installation on any type of floor that will carry its 11,000 pound deal wegiht without transmitting vibrations to the surroundings. A micro-switch can be set to cut off the current to the motor when the amplitude of motion of the loading yoke increases to a predetermined value. Manufacturer: The Baldwin Locomotive Works, Philadelphia.



Cylindrical Thread Roller

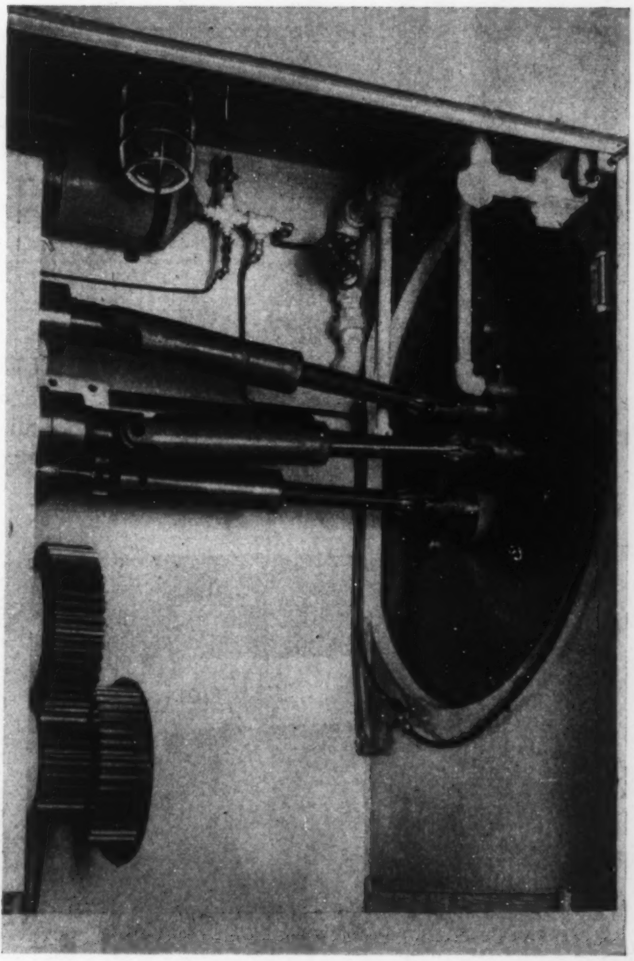
CYLINDRICAL thread rolling machine shown in the photograph, left, uses a simple scroll ring and micrometer adjustment for positioning the dies, their penetration being controlled by a cam-actuated mechanical feeding linkage. As may be seen from the illustration, top next page, the three cylindrical dies are mounted in die holder arms which are pivoted on pins clamped in radial slots 120 degrees apart. Die settings for approximate pitch diameter are made by loosening clamping nuts on the pivot pins and rotating two scroll rings in back of the face plate,



moving the pivot pins radially in their slots an amount indicated by a scale on the face plate. One scroll ring carries the front die pivot bearing and the other ring holds the rear bearing. By rotating the rings independently, either end of the pivot pins can be adjusted separately, allowing the axis of each die to be set parallel to the others and to the blank, thereby correcting any taper in the threads.

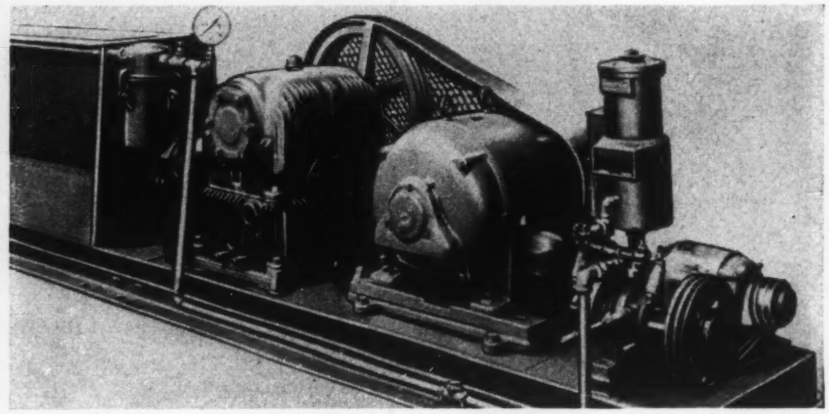
Final pitch diameter die settings are made with the micrometer adjustment shown in the upper center of the close-up view above. Changing the micrometer setting varies the length of the link between the die holders and the cam lever (seen at extreme right), moving the dies in or out by pivoting the die holders about the pivot pins. Penetration of the dies is accurately controlled by a positive gear-driven cam acting on the cam lever which, in turn, moves the dies in or out as described. Any desired controlled penetration rate as well as any predetermined length of dwell can be ground into the cam.

The dies are driven through splined universal joint assemblies shown in the photograph, right. In order for the dies to track in the helix of the thread being rolled, they are first "matched" by bringing them into light contact with a blank and rotating it about $^1/_3$ turn. From the light markings on the blank, adjustments can be made by resetting the graduated marking device on each spindle drive. The machine, capable of single rolling cycles or through-feed rolling of continuous threads, will handle stock diameters to 4 inches. Manufacturer: Reed Rolled Thread Die Co., Worcester, Mass.



Applications

of engineering parts, materials and processes



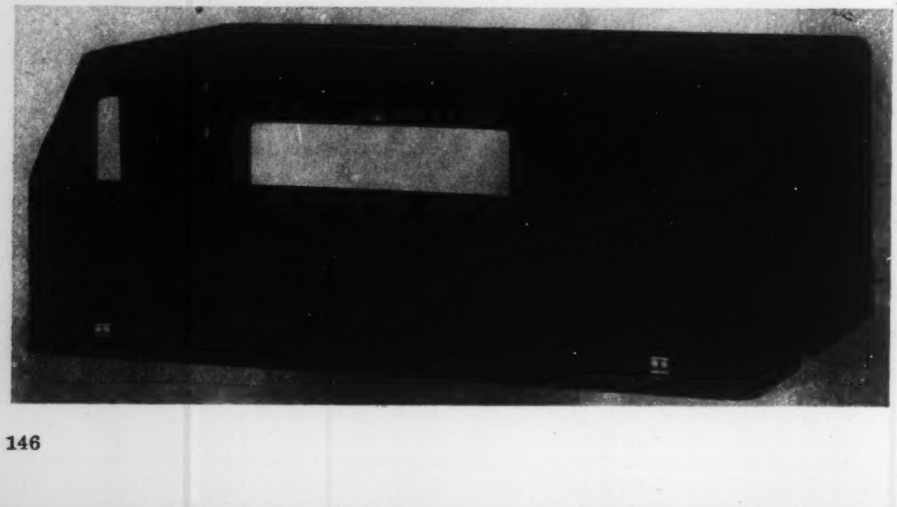
Facilitates Compact Design

COMPACT in-line design of International Clay Machinery's combination pug mill and extruder, above, was made possible by means of the Cone-Drive right-angle speed reducer seen in the center of the illustration. Transmitting 15 horsepower, the speed reducer has a center distance of only five inches. Previous design, using an in-line reducer, required offset installation of the driving motor and consequently greater width of the assembly.

ROADBENT-
OHNSTON, INC.
EL MONTE
CALIF.

Pump Molded of Phenolic

IMPELLER and casing of the water circulating pump, left, are made of Durez phenolic plastic to minimize corrosion and clogging, and effect production economy. Parts, molded in two halves of chemical-resistant, low water-absorption resin and assembled with a phenolic sealer, have high gloss to minimize fluid friction when in service.



Case Drawn in One Step

RADAR-COMPUTOR case, left, was deep drawn from 0.064-inch magnesium alloy in a single step. The one-draw forming by Brooks & Perkins of this 26 by 16 by 11-inch deep shell is said to represent a significant advance in the art of sheet-metal working.

Selecting Limits and Fits for Machine Parts

By H. G. Conway
Technical Director
British Messier Ltd.
Gloucester, England

A GUIDE to the selection of standard sizes, fits and tolerances, the accompanying data sheets are a translation into the inch system of the ISA tolerance system. The system represents the most scientific and comprehensive approach yet attempted. In the absence of an up-to-date standard, therefore, it is hoped that these data sheets will assist designers in establishing uniform limits and standardized dimensions for economical manufacture of mating machine parts

MANY engineers prefer to create arbitrary standards for fits and tolerances for each assembly or component, while others adopt fits and limits extracted from published systems. Such systems are those published by the American Standards Association, the British Standards Institution and the now defunct International Standards Association.

The tolerance system of the ISA was based largely

TABLE I—Fundamental Tolerances of Grades 1 to 16

Nominal Diameters (inches)	Tolerance Unit i	For Gages				For Gages and Fits			For Fits				Large Tolerances (not for Fits)				
		Grades (Tolerances in 0.001-inch)															
		IT_1	IT_2	IT_3	IT_4	IT_5 =7i	IT_6 =10i	IT_7 =16i	IT_8 =25i	IT_9 =40i	IT_{10} =64i	IT_{11} =100i	IT_{12} =160i	IT_{13} =250i	IT_{14} =400i	IT_{15} =640i	IT_{16} =1000i
Over .04 Thru .16	.0225198	.06	.08	.10	.15	0.2	0.3	0.4	0.6	0.9	1.4	2.3	3.6	5.5	9.0	14	23
Over .16 Thru .315	.0318761	.06	.08	.10	.15	0.2	0.3	0.5	0.8	1.3	2.0	3.2	5.0	8.0	13	20	32
Over .315 Thru .5	.0386679	.06	.08	.10	.15	0.3	0.4	0.6	1.0	1.5	2.5	3.9	6.0	9.5	15	25	39
Over .5 Thru .8	.0453351	.06	.08	.10	.20	0.3	0.5	0.7	1.1	1.8	2.9	4.5	7.5	11	18	29	45
Over .8 Thru 1.25	.0530783	.06	.08	.15	.25	0.4	0.5	0.8	1.3	2.1	3.4	5.5	8.5	13	21	34	53
Over 1.25 Thru 2.0	.0622520	.08	.12	.15	.30	0.4	0.6	1.0	1.6	2.5	4.0	6.0	10	16	25	40	62
Over 2.0 Thru 3.15	.0732850	.08	.12	.20	.35	0.5	0.7	1.2	1.8	2.9	4.7	7.5	12	18	29	47	73
Over 3.15 Thru 5.0	0864211	.12	.16	.25	.40	0.6	0.9	1.4	2.2	3.5	5.5	8.5	14	22	35	55	86
Over 5.0 Thru 6.3	.0981622	.12	.20	.30	.45	0.7	1.0	1.6	2.5	3.9	6.5	10	16	25	39	62	98
Over 6.3 Thru 8.0	.107190	.16	.24	.35	.50	0.8	1.1	1.7	2.7	4.3	7.0	11	17	27	43	69	107
Over 8.0 Thru 10.0	.117047	.20	.28	.40	.55	0.8	1.2	1.9	2.9	4.7	7.5	12	19	29	47	75	117
Over 10.0 Thru 12.5	.127639	.24	.32	.45	.65	0.9	1.3	2.0	3.2	5.0	8.0	13	20	32	51	82	128
Over 12.5 Thru 16.0	.140082	.28	.36	.55	.75	1.0	1.4	2.2	3.5	5.5	9.0	14	22	35	56	90	140
Over 16.0 Thru 20.0	.154090	.32	.40	.65	.85	1.1	1.5	2.5	3.9	6.0	10	15	25	39	62	99	154

TABLE II—Shaft Diameter Tolerances for Specific Fits (Values in 0.001-inch)

Fit	Grade	Limit	Shaft Diameter Ranges (inches)																									
			Over 0.04" Thru 0.16"	Over 0.16" Thru 0.315"	Over 0.315" Thru 0.4"	Over 0.4" Thru 0.5"	Over 0.5" Thru 0.63"	Over 0.63" Thru 0.8"	Over 0.8" Thru 1.0"	Over 1.0" Thru 1.25"	Over 1.25" Thru 1.6"	Over 1.6" Thru 2.0"	Over 2.0" Thru 2.5"	Over 2.5" Thru 3.15"	Over 3.15" Thru 4.0"	Over 4.0" Thru 5.0"	Over 5.0" Thru 5.6"	Over 5.6" Thru 6.3"	Over 6.3" Thru 7.1"	Over 7.1" Thru 8.0"	Over 8.0" Thru 9.0"	Over 9.0" Thru 10.0"	Over 10.0" Thru 11.2"	Over 11.2" Thru 12.5"	Over 12.5" Thru 14.0"	Over 14.0" Thru 16.0"	Over 16.0" Thru 18.0"	Over 18.0" Thru 20.0"
a	9 11	Upper—	11	11	11		11		12		12	13	13	14	15	16	19	21	23	26	30	33	37	41	46	52	59	66
	9	Lower—	11.9	12.3	12.5		12.8		14.1		14.5	15.5	15.9	16.9	18.5	19.5	22.9	24.9	27.3	30.3	34.7	37.7	42	46	51.5	57.5	65	72
	11	Lower—	13.3	14.2	14.9		15.5		17.5		18	19	20.5	21.5	23.5	24.5	29	31	34	37	42	45	50	54	60	66	74	81
b	8 9 11	Upper—	5.5	5.5	6		6		6.5		6.5	7	7.5	8	8.5	9.5	9.5	11	12	14	15	17	19	21	24	27	31	34
	8	Lower—	6.1	6.3	7		7.1		7.8		8.1	8.6	9.3	9.8	10.7	11.7	12	13.5	14.7	16.7	17.9	19.9	22.2	24.2	27.5	30.5	34.9	37.9
	9	Lower—	6.4	6.8	7.5		7.8		8.6		9	9.5	10.4	10.9	12	13	13.4	14.9	16.3	18.3	19.7	21.7	24	26	29.5	32.5	37	40
	11	Lower—	7.8	8.7	9.9		10.5		12		12.5	13	15	15.5	17	18	19.5	21	23	25	27	29	32	34	38	41	46	49
c	8 9 11	Upper—	2.4	2.9	3.2		3.6		3.9		4.2	4.4	5.5	6	6.5	7.5	8	8.5	9	10	11	11	12	13	14	16	17	19
	8	Lower—	3	3.7	4.2		4.7		5.2		5.8	6	7.3	7.8	8.7	9.7	10.5	11	11.7	12.7	13.9	13.9	15.2	16.2	17.5	19.5	20.9	22.9
	9	Lower—	3.3	4.2	4.7		5.4		6		6.7	6.9	8.4	8.9	10	11	11.9	12.4	13.3	14.3	15.7	15.7	17	18	19.5	21.5	23	25
	11	Lower—	4.7	6.1	7.1		8.1		9.4		10.2	10.4	13	13.5	15	16	18	18.5	20	21	23	23	25	26	28	30	32	34
d	8 9 10 11	Upper—	.9	1.4	1.7		2.1		2.6		3.2		3.9		4.8		5.5		6		7		7.5		8.5		9.5	
	8	Lower—	1.5	2.2	2.7		3.2		3.9		4.8		5.7		7		8		8.7		9.9		10.7		12		13.4	
	9	Lower—	1.8	2.7	3.2		3.9		4.7		5.7		6.8		8.3		9.4		10.3		11.7		12.5		14		15.5	
	10	Lower—	2.3	3.4	4.2		5		6		7.2		8.6		10.3		12		13		14.5		15.5		17.5		19.5	
	11	Lower—	3.2	4.6	5.6		6.6		8.1		9.2		11.4		13.3		15.5		17		19		20.5		22.5		24.5	
e	7 8 9	Upper—	.6	.9	1.1		1.4		1.6		2		2.4		2.9		3.3		3.6		4		4.4		4.8		5.5	
	7	Lower—	.95	1.4	1.7		2.1		2.4		3		3.6		4.3		4.9		5.3		5.9		6.4		7		8	
	8	Lower—	1.2	1.7	2.1		2.5		2.9		3.6		4.2		5.1		5.8		6.3		6.9		7.6		8.3		9.4	
	9	Lower—	1.5	2.2	2.6		3.2		3.7		4.5		5.3		6.4		7.2		7.9		8.7		9.4		10.3		11.5	
f	6 7 8	Upper—	.3	.4	.6		.7		.8		1		1.2		1.4		1.7		1.8		2		2.2		2.4		2.7	
	6	Lower—	.55	.7	1		1.15		1.3		1.6		1.9		2.3		2.7		2.9		3.2		3.5		3.8		4.2	
	7	Lower—	.65	.9	1.2		1.4		1.6		2		2.4		2.8		3.3		3.5		3.9		4.2		4.6		5.2	
	8	Lower—	.9	1.2	1.6		1.8		2.1		2.6		3		3.6		4.2		4.5		4.9		5.4		5.9		6.6	
g	5 6	Upper—	.1	.2	.2		.3		.3		.3		.4		.5		.5		.6		.6		.7		.7		.8	
	5	Lower—	.3	.4	.45		.6		.65		.75		.9		1.1		1.2		1.4		1.4		1.6		1.7		1.9	
	6	Lower—	.35	.5	.6		.75		.8		.9		1.1		1.4		1.5		1.7		1.8		2		2.1		2.3	
h	5 6 7 8 9 10 11	Upper—	0	0	0		0		0		0		0		0		0		0		0		0		0		0	
	5	Lower—	.2	.2	.25		.3		.35		.45		.5		.6		.7		.8		.8		.9		1		1.1	
	6	Lower—	.25	.3	.4		.45		.5		.6		.7		.9		1		1.1		1.2		1.3		1.4		1.5	
	7	Lower—	.35	.5	.6		.7		.8		1		1.2		1.4		1.6		1.7		1.9		2		2.2		2.5	
	8	Lower—	.6	.8	1		1.1		1.3		1.6		1.8		2.2		2.5		2.7		2.9		3.2		3.5		3.9	
	9	Lower—	.9	1.3	1.5		1.8		2.1		2.5		2.9		3.5		3.9		4.3		4.7		5		5.5		6	
	10	Lower—	1.4	2	2.5		2.9		3.4		4		4.7		5.5		6.5		7		7.5		8		9		10	
	11	Lower—	2.3	3.2	3.9		4.5		5.5		6		7.5		8.5		10		11		12		13		14		15	
j	5	Upper+	.15	.15	.15		.2		.2		.25		25		.25		.25		.25		.25		.25		.3		.3	
	6	Upper+	.2	.25	.3		.35		.35		.4		.45		.5		.6		.6		.6		.6		.7		.7	
	5 6	Lower—	.05	.05	.1		.1		.15		.2		.25		.4		.45		.5		.6		.7		.7		.8	
	7	Upper+	.25	.35	.4		.4		.5		.6		.7		.8		.9		.9		1		1		1.1		1.3	
		Lower—	.1	.15	.2		.3		.3		.4		.5		.6		.7		.8		.9		1		1.1		1.2	
	8	Upper+	.3	.4	.5		.6		.7		.8		.9		1.1		1.3		1.4		1.5		1.6		1.8		2	
		Lower—	.3	.4	.5		.5		.6		.8		.9		1.1		1.2		1.3		1.4		1.0		1.7		1.9	
	9	Upper+	.5	.7	.8		.9		1.1		1.3		1.5		1.8		2		2.2		2.4		2.5		2.8		3	
		Lower—	.4	.6	.7		.9		1		1.2		1.4		1.7		1.9		2.1		2.3		2.5		2.7		3	
	10	Upper+	.7	1	1.3		1.5		1.7		2		2.4		2.8		3.3		3.5		3.8		4		4.5		5	
		Lower—	.7	1	1.2		1.4		1.7		2		2.3		2.7		3.2		3.5		3.7		4		4.5		5	
	11	Upper+	1.3	1.6	2		2.3		2.8		3		3.8		4.3		5		5.5		6		6.5		7		7.5	

	11	Upper+	1.2	1.6	2		2.3		2.8		3		3.8		4.3		5		5.5		6		6.5		7		7.5	
		Lower—	1.1	1.6	1.9		2.2		2.7		3		3.7		4.2		5		5.5		6		6.5		7		7.5	
k	5	Upper+	...	...	.25		.3		.35		.55		.6		.7		.8		.9		.9		1.1		1.2		1.3	
	6	Upper+	...	...	.4		.45		.5		.7		.8		1		1.1		1.2		1.3		1.5		1.6		1.7	
	7	Upper+	...	...	.6		.7		.8		1.1		1.3		1.5		1.7		1.8		2		2.2		2.4		2.7	
	5 6 7	Lower+	...	...	.0		.0		.0		.1		.1		.1		.1		.1		.1		.2		.2		.2	
	8	Upper+	.6	.8	1		1.1		1.3		1.6		1.8		2.2		2.5		2.7		2.9		3.2		3.5		3.9	
	9	Upper+	.9	1.3	1.5		1.8		2.1		2.5		2.9		3.5		3.9		4.3		4.7		5		5.5		6	
	10	Upper+	1.4	2	2.5		2.9		3.4		4		4.7		5.5		6.5		7		7.5		8		9		10	
	11	Upper+	2.3	3.2	3.9		4.5		5.5		6		7.5		8.5		10		11		12		13		14		15	
	8 9 10 11	Lower+	0	0	0		0		0		0		0		0		0		0		0		0		0		0	
m	5	Upper+	.3	.4	.45		.55		.65		.85		1		1.1		1.3		1.4		1.5		1.6		1.8		1.9	
	6	Upper+	.35	.5	.6		.7		.8		1		1.2		1.4		1.6		1.7		1.9		2		2.2		2.3	
	7	Upper+	...	...	.8		.95		1.1		1.4		1.7		1.9		2.2		2.3		2.6		2.7		3		3.3	
	5 6 7	Lower+	.1	.2	.2		.25		.3		.4		.5		.5		.6		.6		.7		.7		.8		.8	
n	5	Upper+	.5	.6	.75		.9		.95		1.15		1.3		1.6		1.8		2		2.1		2.3		2.5		2.7	
	6	Upper+	.55	.7	.9		1.05		1.1		1.3		1.5		1.9		2.1		2.3		2.5		2.7		2.9		3.1	
	7	Upper+	.65	.9	1.1		1.3		1.4		1.7		2		2.4		2.7		2.9		3.2		3.4		3.7		4.1	
	5 6 7	Lower+	.3	.4	.5		.6		.6		.7		.8		1.0		1.1		1.2		1.3		1.4		1.5		1.6	
p	5	Upper+	.6	.7	.85		1		1.25		1.55		1.8		2.1		2.4		2.6		2.8		3.1		3.4		3.8	
	6	Upper+	.65	.8	1		1.15		1.4		1.7		2		2.4		2.7		2.9		3.2		3.5		3.8		4.2	
	7	Upper+	.75	1	1.2		1.4		1.7		2.1		2.5		2.9		3.3		3.5		3.9		4.2		4.6		5.2	
	5 6 7	Lower+	.4	.5	.6		.7		.9		1.1		1.3		1.5		1.7		1.8		2		2.2		2.4		2.7	
r	5	Upper+	.7	.9	1.05		1.2		1.45		1.85		2.1	2.2	2.6	2.8	3.2	3.3	3.6	3.7	4.1	4.2	4.6	4.7	5.3	5.5	6.1	6.1
	6	Upper+	.75	1	1.2		1.35		1.6		2.0		2.3	2.4	2.9	3.1	3.5	3.6	3.9	4	4.5	4.6	5	5.1	5.7	5.9	6.5	6.5
	7	Upper+	.85	1.2	1.4		1.6		1.9		2.4		2.8	2.9	3.4	3.6	4.1	4.2	4.5	4.6	5.2	5.3	5.7	5.8	6.5	6.7	7.5	7.5
	5 6 7	Lower+	.5	.7	.8		.9		1.1		1.4		1.6	1.7	2	2.2	2.5	2.6	2.8	2.9	3.3	3.4	3.7	3.8	4.3	4.5	5	5
s	5	Upper+	.8	1.1	1.25		1.5		1.75		2.25		2.6	2.8	3.4	3.8	4.4	4.6	5.2	5.5	6.3	6.3	7.4	7.9	8.5	9	10.6	11.1
	6	Upper+	.85	1.2	1.4		1.65		1.9		2.4		2.8	3	3.7	4.1	4.7	4.9	5.5	5.8	6.7	6.7	7.8	8.3	8.9	9.4	11	11.5
	7	Upper+	.95	1.4	1.6		1.9		2.2		2.8		3.3	3.5	4.2	4.6	5.3	5.5	6.1	6.4	7.4	7.4	8.5	9	9.7	10.2	12	12.5
	5 6 7	Lower+	.6	.9	1.1		1.2		1.4		1.8		2.1	2.3	2.8	3.2	3.7	3.9	4.4	4.7	5.5	5.5	6.5	7	7.5	8	9.5	10
t	5	Upper+	...	...	...		...		...	2.05	2.45	2.65	3.1	3.4	4.2	4.8	5.6	6.2	6.8	7.3	7.8	8.8	9.4	10.4	12	13	14.1	15.1
	6	Upper+	...	...	...		...		...	2.2	2.6	2.8	3.3	3.6	4.5	5.1	5.9	6.5	7.1	7.6	8.2	9.2	9.8	10.8	12.4	13.4	14.5	15.5
	7	Upper+	...	...	...		...		...	2.5	3.0	3.2	3.8	4.1	5	5.6	6.5	7.1	7.7	8.2	8.9	9.9	10.5	11.5	13.2	14.2	15.5	16.5
	5 6 7	Lower+	...	...	...		...		...	1.7	2.0	2.2	2.6	2.9	3.6	4.2	4.9	5.5	6	6.5	7	8	8.5	9.5	11	12	13	14
u	5	Upper+	.9	1.1	1.35	1.55	1.8		2.05	2.35	2.85	3.25	3.9	4.5	5.5	6.6	7.7	8.2	9.3	10.3	10.8	11.8	13.9	14.9	16	18	20.1	22.1
	6	Upper+	.95	1.2	1.5	1.7	1.95		2.2	2.5	3	3.4	4.1	4.7	5.8	6.9	8	8.5	9.6	10.6	11.2	12.2	14.3	15.3	16.4	18.4	20.5	22.5
	7	Upper+	1.05	1.4	1.7	1.9	2.2		2.5	2.8	3.4	3.8	4.6	5.2	6.3	7.4	8.6	9.1	10.2	11.2	11.9	12.9	15	16	17.2	19.2	21.5	23.5
	5 6 7	Lower+	.7	.9	1.1	1.3	1.5		1.7	2	2.4	2.8	3.4	4	4.9	6	7	7.5	8.5	9.5	10	11	13	14	15	17	19	21
v	5	Upper+	...	...	...	...	1.8	2.0	2.35	2.55	3.25	3.65	4.5	5.2	6.6	7.6	8.7	9.7	10.8	11.8	12.8	14.8	15.9	17.9	20	22	25.1	27.1
	6	Upper+	...	...	...	...	1.95	2.15	2.5	2.7	3.4	3.8	4.7	5.4	6.9	7.9	9	10	11.1	12.1	13.2	15.2	16.3	18.3	20.4	22.4	25.5	27.5
	7	Upper+	...	...	...	...	2.2	2.4	2.8	3	3.8	4.2	5.2	5.9	7.4	8.4	9.6	10.6	11.7	12.7	13.9	15.9	17	19	21.2	23.2	26.5	28.5
	5 6 7	Lower+	...	...	...	...	1.5	1.7	2	2.2	2.8	3.2	4	4.7	6	7	8	9	10	11	12	14	15	17	19	21	24	26
x	5	Upper+	1.1	1.3	1.55	1.75	2.0	2.3	2.65	2.95	3.75	4.35	5.3	6	7.6	9.1	10.7	11.7	12.8	14.8	15.8	17.8	19.9	21.9	24	27	31.1	34.1
	6	Upper+	1.15	1.4	1.7	1.9	2.15	2.45	2.8	3.1	3.9	4.5	5.5	6.2	7.9	9.4	11	12	13.1	15.1	16.2	18.2	20.3	22.3	24.4	27.4	31.5	34.5
	7	Upper+	1.25	1.6	1.9	2.1	2.4	2.7	3.1	3.4	4.3	4.9	6	6.7	8.4	9.9	11.6	12.6	13.7	15.7	16.9	18.9	21	23	25.2	28.2	32.5	35.5
	5 6 7	Lower+	.9	1.1	1.3	1.5	1.7	2.0	2.3	2.6	3.3	3.9	4.8	5.5	7	8.5	10	11	12	14	15	17	19	21	23	26	30	33
y	6	Upper+	...	...	...	...	...	2.65	3.1	3.6	4.4	5.2	6.2	7.7	9.4	10.9	13	14	16.1	18.1	20.2	22.2	24.3	27.3	30.4	33.4	37.5	41.5
	7	Upper+	...	...	...	...	...	2.9	3.4	3.9	4.8	5.6	6.7	8.2	9.9	11.4	13.6	14.6	16.7	18.7	20.9	22.9	25	28	31.2	34.2	38.5	42.5
	6 7	Lower+	...	...	...	...	...	2.2	2.6	3.1	3.8	4.6	5.5	7	8.5	10	12	13	15	17	19	21	23	26	29	32	36	40
z	6	Upper+	1.45	1.8	2.2	2.4	2.65	3.05	3.6	4.1	5.1	6.1	7.7	8.7	10.9	13.9	16	17	19.1	22.1	24.2	27.2	29.3	33.3	36.4	41.4	46.5	51.5
	7	Upper+	1.55	2.0	2.4	2.6	2.9	3.3	3.9	4.4	5.5	6.5	8.2	9.2	11.4	14.4	16.6	17.6	19.7	22.7	24.9	27.9	30	34	37.2	42.2	47.5	52.5
	6 7	Lower+	1.2	1.5	1.8	2.0	2.2	2.6	3.1	3.6	4.5	5.5	7	8	10	13	15	16	18	21	23	26	28	32	35	40	45	50

ENGINEERING DATA SHEET

TABLE III—Hole Diameter Tolerances for Specific Fits (Values in 0.001-inch)

Fit	Grade	Limit	Hole Diameter Ranges (inches)																									
			Over 0.04″ Thru 0.16″	Over 0.16″ Thru 0.315″	Over 0.315″ Thru 0.4″	Over 0.4″ Thru 0.5″	Over 0.5″ Thru 0.63″	Over 0.63″ Thru 0.8″	Over 0.8″ Thru 1.0″	Over 1.0″ Thru 1.25″	Over 1.25″ Thru 1.6″	Over 1.6″ Thru 2.0″	Over 2.0″ Thru 2.5″	Over 2.5″ Thru 3.15″	Over 3.15″ Thru 4.0″	Over 4.0″ Thru 5.0″	Over 5.0″ Thru 5.6″	Over 5.6″ Thru 6.3″	Over 6.3″ Thru 7.1″	Over 7.1″ Thru 8.0″	Over 8.0″ Thru 9.0″	Over 9.0″ Thru 10.0″	Over 10.0″ Thru 11.2″	Over 11.2″ Thru 12.5″	Over 12.5″ Thru 14.0″	Over 14.0″ Thru 16.0″	Over 16.0″ Thru 18.0″	Over 18.0″ Thru 20.0″
A	9	Upper+	11.9	12.3	12.5		12.8		14.1		14.5	15.5	15.9	16.9	18.5	19.5	22.9	24.9	27.3	30.3	34.7	37.7	42	46	51.5	57.5	65	72
	11	Upper+	13.3	14.2	14.9		15.5		17.5		18	19	20.5	21.5	23.5	24.5	29	31	34	37	42	45	50	54	60	66	74	81
	9 11	Lower+	11	11	11		11		12		12	13	13	14	15	16	19	21	23	26	30	33	37	41	46	52	59	66
B	8	Upper+	6.1	6.3	7		7.1		7.8		8.1	8.6	9.3	9.8	10.7	11.7	12.9	13.5	14.7	16.7	17.9	19.9	22.2	24.2	27.5	30.5	34.9	37.9
	9	Upper+	6.4	6.8	7.5		7.8		8.6		9	9.5	10.4	10.9	12	13	13.4	14.9	16.3	18.3	19.7	21.7	24	26	29.5	32.5	37	40
	11	Upper+	7.8	8.7	9.9		10.5		12		12.5	13	15	15.5	17	18	19.5	21	23	25	27	29	32	34	38	41	46	49
	8 9 11	Lower+	5.5	5.5	6		6		6.5		6.5	7	7.5	8	8.5	9.5	9.5	11	12	14	15	17	19	21	24	27	31	34
C	8	Upper+	3	3.7	4.2		4.7		5.2		5.8	6	7.3	7.8	8.7	9.7	10.5	11.0	11.7	12.7	13.9	13.9	15.2	16.2	17.5	19.5	20.9	22.9
	9	Upper+	3.3	4.2	4.7		5.4		6		6.7	6.9	8.4	8.9	10	11	11.9	12.4	13.3	14.3	15.7	15.7	17	18	19.5	21.5	23	25
	11	Upper+	4.7	6.1	7.1		8.1		9.4		10.2	10.4	13	13.5	15	16	18	18.5	20	21	23	23	25	26	28	30	32	34
	8 9 11	Lower+	2.4	2.9	3.2		3.6		3.9		4.2	4.4	5.5	6	6.5	7.5	8	8.5	9	10	11	11	12	13	14	16	17	19
D	8	Upper+	1.5	2.2	2.7		3.2		3.9		4.8		5.7		7		8		8.7		9.9		10.7		12		13.4	
	9	Upper+	1.8	2.7	3.2		3.9		4.7		5.7		6.8		8.3		9.4		10.3		11.7		12.5		14		15.5	
	10	Upper+	2.3	3.4	4.2		5		6		7.2		8.6		10.3		12		13		14.5		15.5		17.5		19.5	
	11	Upper+	3.2	4.6	5.6		6.6		8.1		9.2		11.4		13.3		15.5		17		19		20.5		22.5		24.5	
	8 9 10 11	Lower+	.9	1.4	1.7		2.1		2.6		3.2		3.9		4.8		5.5		6		7		7.5		8.5		9.5	
E	7	Upper+	.95	1.4	1.7		2.15		2.45		3		3.6		4.3		4.9		5.3		5.9		6.4		7		8	
	8	Upper+	1.2	1.7	2.1		2.5		2.6		3.6		4.2		5.1		5.8		6.3		6.9		7.6		8.3		9.4	
	9	Upper+	1.5	2.2	2.6		3.2		3.7		4.5		5.3		6.4		7.2		7.9		8.7		9.4		10.3		11.5	
	7 8 9	Lower+	.6	.9	1.1		1.4		1.6		2		2.4		2.9		3.3		3.6		4		4.4		4.8		5.5	
F	6	Upper+	.55	.7	1		1.15		1.3		1.6		1.9		2.3		2.7		2.9		3.2		3.5		3.8		4.2	
	7	Upper+	.65	.9	1.2		1.4		1.6		2		2.4		2.8		3.3		3.5		3.9		4.2		4.6		5.2	
	8	Upper+	.9	1.2	1.5		1.8		2.1		2.6		3		3.6		4.2		4.5		4.9		5.4		5.9		6.6	
	9	Upper+	1.2	1.7	2.1		2.5		2.9		...		...		...		...		...		...		...		...		...	
	6 7 8 9	Lower+	.3	.4	.6		.7		.8		1		1.2		1.4		1.7		1.8		2		2.2		2.4		2.7	
G	6	Upper+	.35	.5	.6		.75		.8		.9		1.1		1.4		1.5		1.7		1.8		2		2.1		2.3	
	7	Upper+	.45	.7	.8		1		1.1		1.3		1.6		1.9		2.1		2.3		2.5		2.7		2.9		3.3	
	6 7	Lower+	.1	.2	.2		.3		.3		.3		.4		.5		.5		.6		.6		.7		.7		.8	
H	6	Upper+	.25	.3	.4		.45		.5		.6		.7		.9		1		1.1		1.2		1.3		1.4		1.5	
	7	Upper+	.35	.5	.6		.7		.8		1		1.2		1.4		1.6		1.7		1.9		2		2.2		2.5	
	8	Upper+	.6	.8	1		1.1		1.3		1.6		1.8		2.2		2.5		2.7		2.9		3.2		3.5		3.9	
	9	Upper+	.9	1.3	1.5		1.8		2.1		2.5		2.9		3.5		3.9		4.3		4.7		5		5.5		6	
	10	Upper+	1.4	2	2.5		2.9		3.4		4		4.7		5.5		6.5		7		7.5		8		9		10	
	11	Upper+	2.3	3.2	3.9		4.5		5.5		6		7.5		8.5		10		11		12		13		14		15	
	6 7 8 9 10 11	Lower+	0	0	0		0		0		0		0		0		0		0		0		0		0		0	
J	6	Upper+	.1	.15	.25		.25		.3		.35		.45		.6		.8		.9		1.0		1.1		1.1		1.2	
		Lower—	.15	.15	.15		.2		.2		.25		.25		.25		.25		.25		.25		.25		.3		.3	
	7	Upper+	.15	.25	.3		.35		.45		.6		.75		.9		1		1.1		1.3		1.4		1.5		1.8	
		Lower—	.2	.25	.3		.35		.35		.4		.45		.5		.6		.6		.6		.6		.7		.7	
	8	Upper+	.35	.45	.6		.7		.8		1		1.1		1.4		1.6		1.8		1.9		2.2		2.4		2.6	
		Lower—	.25	.35	.4		.4		.5		.6		.7		.8		.9		.9		1		1		1.1		1.3	
	9	Upper+	.4	.6	.7		.9		1		1.2		1.4		1.7		1.9		2.1		2.3		2.5		2.7		3	
		Lower—	.5	.7	.8		.9		1.1		1.3		1.5		1.8		2		2.2		2.4		2.5		2.8		3	
	10	Upper+	.7	1	1.2		1.4		1.7		2		2.3		2.7		3.2		3.5		3.7		4		4.5		5	
		Lower—	.7	1	1.3		1.5		1.7		2		2.4		2.8		3.3		3.5		3.8		4		4.5		5	
	11	Upper+	1.1	1.6	1.9		2.2		2.7		3		3.7		4.2		5		5.5		6		6.5		7		8	
		Lower—	1.2	1.6	2		2.3		2.8		3		3.8		4.3		5		5.5		6		6.5		7		8	

	6	Upper+	...	...	.15		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]	
		Lower—	...	...	.25		.3		.35		.5		.6		.7		.8		.9		1.0		1.1		1.2		1.3	
K	7	Upper+	...	...	.2		.25		.3		.3		.4		.4		.5		.5		.6		.6		.7		.8	
		Lower—	...	...	.4		.45		.5		.7		.8		1		1.1		1.2		1.3		1.4		1.5		1.7	
	8	Upper+	...	...	.4		.4		.5		.5		.5		.7		.8		.9		.9		1		1.1		1.2	
		Lower—	...	...	.6		.7		.8		1.1		1.3		1.5		1.7		1.8		2		2.2		2.4		2.7	
	6	Upper—	.05	.1	.1		.1		.2		.2		.2		.3		.3		.3		.3		.3		.4		.4	
		Lower—	.3	.4	.45		.55		.65		.85		1		1.1		1.3		1.4		1.5		1.6		1.8		1.9	
M	7	Upper—	0	0	0		0		0		0		0		0		0		0		0		0		0		0	
		Lower—	.35	.5	.6		.7		.8		1		1.2		1.4		1.6		1.7		1.9		2		2.2		2.5	
	8	Upper+	...	...	.1		.1		.2		.2		.2		.3		.3		.3		.4		.4		.5		.6	
		Lower—	...	...	.8		.95		1.1		1.4		1.7		1.9		2.2		2.3		2.6		2.7		3		3.3	
	6	Upper—	.25	.3	.35		.45		.5		.6		.6		.7		.8		.9		.9		1		1.1		1.2	
		Lower—	.5	.6	.75		.9		1		1.2		1.3		1.6		1.8		2		2.1		2.3		2.5		2.7	
	7	Upper—	.2	.2	.3		.3		.3		.3		.4		.4		.5		.6		.6		.7		.7		.7	
		Lower—	.55	.7	.9		1		1.1		1.3		1.5		1.9		2.1		2.3		2.5		2.7		2.9		3.1	
N	8	Upper—	.05	.1	.1		.1		.1		.1		.1		.2		.2		.2		.2		.2		.2		.2	
		Lower—	.65	.9	1.1		1.3		1.4		1.7		2		2.4		2.7		2.9		3.2		3.4		3.7		4.1	
	9 10 11	Upper—	0	0	0		0		0		0		0		0		0		0		0		0		0		0	
	9	Lower—	.9	1.3	1.5		1.8		2.1		2.5		2.9		3.5		3.9		4.3		4.7		5		5.5		6	
	10	Lower—	1.4	2	2.5		2.9		3.4		4		4.7		5.5		6.5		7		7.5		8		9		10	
	11	Lower—	2.3	3.2	3.9		4.5		5.5		6		7.5		8.5		10		11		12		13		14		15	
	6	Upper—	.35	.4	.5		.55		.8		1.0		1.1		1.2		1.4		1.5		1.6		1.8		2		2.3	
		Lower—	.6	.7	.9		1		1.3		1.6		1.8		2.1		2.4		2.6		2.8		3.1		3.4		3.8	
P	7	Upper—	.3	.3	.4		.5		.6		.7		.8		1		1.1		1.2		1.3		1.5		1.6		1.7	
		Lower—	.65	.8	1		1.2		1.4		1.7		2		2.4		2.7		2.9		3.2		3.5		3.8		4.2	
	6	Upper—	.45	.6	.7		.75		1		1.3		1.4	1.5	1.7	1.9	2.2	2.3	2.5	2.6	2.9	3	3.3	3.4	3.9	4.1	4.6	4.6
		Lower—	.7	.9	1.1		1.2		1.5		1.9		2.1	2.2	2.6	2.8	3.2	3.3	3.6	3.7	4.1	4.2	4.6	4.7	5.3	5.5	6.1	6.1
R	7	Upper—	.4	.5	.6		.7		.8		1		1.1	1.2	1.5	1.7	1.9	2	2.2	2.3	2.6	2.7	3	3.1	3.5	3.7	4	4
		Lower—	.75	1	1.2		1.4		1.6		2		2.3	2.4	2.9	3.1	3.5	3.6	3.9	4	4.5	4.6	5	5.1	5.7	5.9	6.5	6.5
	6	Upper—	.55	.8	.9		1.05		1.3		1.7		1.9	2.1	2.5	2.9	3.4	3.6	4.1	4.4	5.1	5.1	6.1	6.6	7.1	7.6	9.1	9.6
		Lower—	.8	1.1	1.3		1.5		1.8		2.3		2.6	2.8	3.4	3.8	4.4	4.6	5.2	5.5	6.3	6.3	7.4	7.9	8.5	9	10.6	11.1
S	7	Upper—	.5	.7	.8		1		1.1		1.4		1.6	1.8	2.3	2.7	3.1	3.3	3.8	4.1	4.8	4.8	5.8	6.3	6.7	7.2	8.5	9
		Lower—	.85	1.2	1.4		1.7		1.9		2.4		2.8	3	3.7	4.1	4.7	4.9	5.5	5.8	6.7	6.7	7.8	8.3	8.9	9.4	11	11.5
	6	Upper—	...	...	...		...		...	1.6	1.9	2.1	2.4	2.7	3.3	3.9	4.6	5.2	5.7	6.2	6.6	7.6	8.1	9.1	10.6	11.6	12.6	13.6
		Lower—	...	...	...		...		...	2.1	2.5	2.7	3.1	3.4	4.2	4.8	5.6	6.2	6.8	7.3	7.8	8.8	9.4	10.4	12	13	14.1	15.1
T	7	Upper—	...	...	...		...		...	1.4	1.6	1.8	2.1	2.4	3.1	3.7	4.3	4.9	5.4	5.9	6.3	7.3	7.8	8.8	10.2	11.2	12	13
		Lower—	...	...	...		...		...	2.2	2.6	2.8	3.3	3.6	4.5	5.1	5.9	6.5	7.1	7.6	8.2	9.2	9.8	10.8	12.4	13.4	14.5	15.5
	6	Upper—	.65	.8	1	1.2	1.35		1.6	1.9	2.3	2.7	3.2	3.8	4.6	5.7	6.7	7.2	8.2	9.2	9.6	10.6	12.6	13.6	14.6	16.6	18.6	20.6
		Lower—	.9	1.1	1.4	1.6	1.8		2.1	2.4	2.9	3.3	3.9	4.5	5.5	6.6	7.7	8.2	9.3	10.3	10.8	11.8	13.9	14.9	16	18	20.1	22.1
U	7	Upper—	.6	.7	.9	1.1	1.3		1.4	1.7	2	2.4	2.9	3.5	4.4	5.5	6.4	6.9	7.9	8.9	9.3	10.3	12.3	13.3	14.2	16.2	18	20
		Lower—	.95	1.2	1.5	1.7	2		2.2	2.5	3	3.4	4.1	4.7	5.8	6.9	8	8.5	9.6	10.6	11.2	12.2	14.3	15.3	16.4	18.4	20.5	22.5
	6	Upper—	...	...	...	...	1.35	1.55	1.9	2.1	2.7	3.1	3.8	4.5	5.7	6.7	7.7	8.7	9.7	10.7	11.6	13.6	14.6	16.6	18.6	20.6	23.6	25.6
		Lower—	...	...	...	...	1.8	2	2.4	2.6	3.3	3.7	4.5	5.2	6.6	7.6	8.7	9.7	10.8	11.8	12.8	14.8	15.9	17.9	20	22	25.1	27.1
V	7	Upper—	...	...	...	...	1.3	1.5	1.7	1.9	2.4	2.8	3.5	4.2	5.5	6.5	7.4	8.4	9.4	10.4	11.3	13.3	14.3	16.3	18.2	20.2	23	25
		Lower—	...	...	...	...	2	2.2	2.5	2.7	3.4	3.8	4.7	5.4	6.9	7.9	9	10	11.1	12.1	13.2	15.2	16.3	18.3	20.4	22.4	25.5	27.5
	6	Upper—	.85	1.0	1.2	1.4	1.55	1.85	2.2	2.5	3.2	3.8	4.6	5.3	6.7	8.2	9.7	10.7	11.7	13.7	14.6	16.6	18.6	20.6	22.6	25.6	29.5	32.5
		Lower—	1.1	1.3	1.6	1.8	2	2.3	2.7	3	3.8	4.4	5.3	6	7.6	9.1	10.7	11.7	12.8	14.8	15.8	17.8	19.9	21.9	24	27	31	34
X	7	Upper—	.8	.9	1.1	1.3	1.5	1.8	2	2.3	2.9	3.5	4.3	5	6.5	7.9	9.4	10.4	11.4	13.4	14.3	16.3	18.3	20.3	22.2	25.2	29	32
		Lower—	1.15	1.4	1.7	1.9	2.2	2.5	2.8	3.1	3.9	4.5	5.5	6.2	7.9	9.4	11	12	13.1	15.1	16.2	18.2	20.3	22.3	24.4	27.4	31.5	34.5
Y	7	Upper—	...	...	...	...	...	2	2.3	2.8	3	4.2	5	6.5	8	9.5	11.4	12.4	14.4	16.4	18.3	20.3	22.3	25.3	28.2	31.2	35	39
		Lower—	...	...	...	...	...	2.7	3.1	3.6	4	5.2	6.2	7.7	9.4	10.9	13	14	16.1	18.1	20.2	22.2	24.3	27.3	30.4	33.4	37.5	41.5
Z	7	Upper—	1.1	1.3	1.6	1.8	2	2.4	2.8	3.3	4.1	5.1	6.5	7.5	9.5	12.5	14.4	15.4	17.4	20.4	22.3	25.3	27.3	31.3	34.2	39.2	44	49
		Lower—	1.45	1.8	2.2	2.4	2.7	3.1	3.6	4.1	5.1	6.1	7.7	8.7	10.9	13.9	16	17	19.1	22.1	24.2	27.2	29.3	33.3	36.4	41.4	46.5	51.5

on German experience and is thus in metric units. Being a much later system than that of the ASA or BSI it is in many respects the best and is certainly the most thorough in a typically German manner. Although it may appear at first inspection to be excessively complicated, this is in fact not so; comprehensiveness need not involve complication.

The tables (Pages 148-151) have been worked out in detail, using the original ISA formulas. The numbers are rounded off or approximated in accordance with definite rules suitable for the inch system. The qualities of the various fits specified are identical with the metric original, although expressed in different units, but without involving the absurd nominal dimensions which a straight conversion would have entailed. Thus the spirit, if not the letter, of the original work is retained in a form considered acceptable to the inch-using engineer.

TABLE IV—**Hole Tolerance Selection for Unilateral Holes**

Grade	Class	Method	Remarks
H_1-H_5	Gages	Special processes	For gages, etc.
H_6	Extra precision	Grinder	For ball bearings
H_7	Precision	Lathe, broach, honer	
H_8	Normal	Turret lathe	
H_9	Coarse	Milling machine, automatic machines	
H_{10} etc.	Wide	Drilling machine	Not for fits

FEATURES OF THE SYSTEM: The system consists fundamentally of 16 *qualities* of tolerance or, in other words, grades of manufacture; and of 20 grades of *fit* for both hole and shaft ranging from fits of extreme interference to fits of extreme clearance. All possible requirements of every range of engineering or scientific product are covered from very coarse manufacturing limits to those for an accuracy of manufacture exceeding even that achieved by gauge-block makers. It is intended that a particular industry or organization should extract and use those limits which suit its own product, since no one industry could possibly require such a wide range of tolerances.

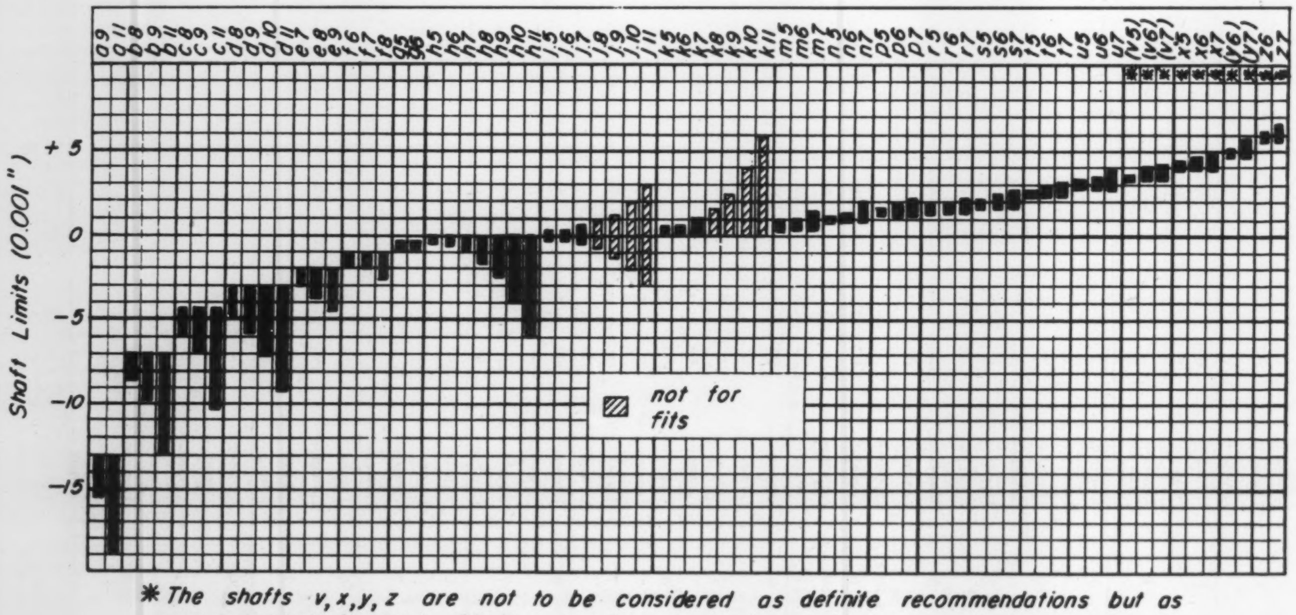
The finest grades of tolerances are also tabled to enable gage manufacturing limits to be included. In fact the system is the only one published which includes specific recommendations for the setting and manufacturing limits of gages which are to be used to measure the limits quoted for the components themselves. The specification goes further and defines the load to be used to pass the gage, the type of gage, and the recommended wear allowances.

Bilateral Holes Also Listed

Although modern manufacturing practice is to use the "basic hole" or "unilateral hole" system with varying fits obtained by variation in shaft size, a full range of "bilateral" holes corresponding in fact to the various shaft steps is also listed. These holes are frequently useful for special purposes as mentioned later.

DIAMETER INCREMENTS: The original metric version used diameter increments or steps based partly

Fig. 1—Shaft limits represented graphically



✱ The shafts v, x, y, z are not to be considered as definite recommendations but as recommended for trial. Shafts v and y are to be avoided as much as possible.

on preferred numbers (10 and 20 series) and partly (in the sizes below 180 mm) on existing European practice which could not be ignored.

In the translation, the steps are based on the same preferred number series but, not having existing practice to take into account, the steps are uncompromised throughout, with the exception of the smallest sizes. The 10 series is used between 0.315-in. and 5 in., and the 20 series above 5 in. up to 20 in. Below 0.315-in. a single division chosen arbitrarily at 0.16-in. is taken between this size and 0.04-in. which is the smallest diameter tabled (1 mm in the original).

The diameter steps are

0.04	1	**5**	11.2
0.16	**1.25**	5.6	**12.5**
0.315	1.6	**6.3**	14
0.4	**2**	7.1	**16**
0.5	2.5	**8**	18
0.63	**3.15**	9	**20**
0.80	4	**10**	

The general or coarse steps are in bold type. The intermediate or fine steps are used only in certain grades of hole or shaft.

FUNDAMENTAL TOLERANCES: The 16 qualities of tolerance referred to in the foregoing are based on a *Fundamental Tolerance Unit* (i) and are multiples of it (IT_1 to IT_{16}). Between IT_6 and IT_{16} the tolerance units are arranged in a geometric series based on the 5-Series preferred numbers. The values of IT_{12} to IT_{16} are thus 10 times the values of IT_6 to IT_{11}. The value of IT_5 is 70 per cent of IT_6. The fundamental tolerance values of IT_1 are arranged in arithmetic progression in a purely arbitrary fashion owing to the extreme difficulty in measuring extremely fine limits (the first value of IT_1 is only 60 microinches). The values of IT_2 to IT_4 are arranged in an approximate geometric progression between IT_1 and IT_5. The fundamental tolerance unit itself is derived from the formula

$$i \text{ (microns)} = 0.45 \sqrt[3]{D} + 0.001\, D \text{ (mm)}$$

or

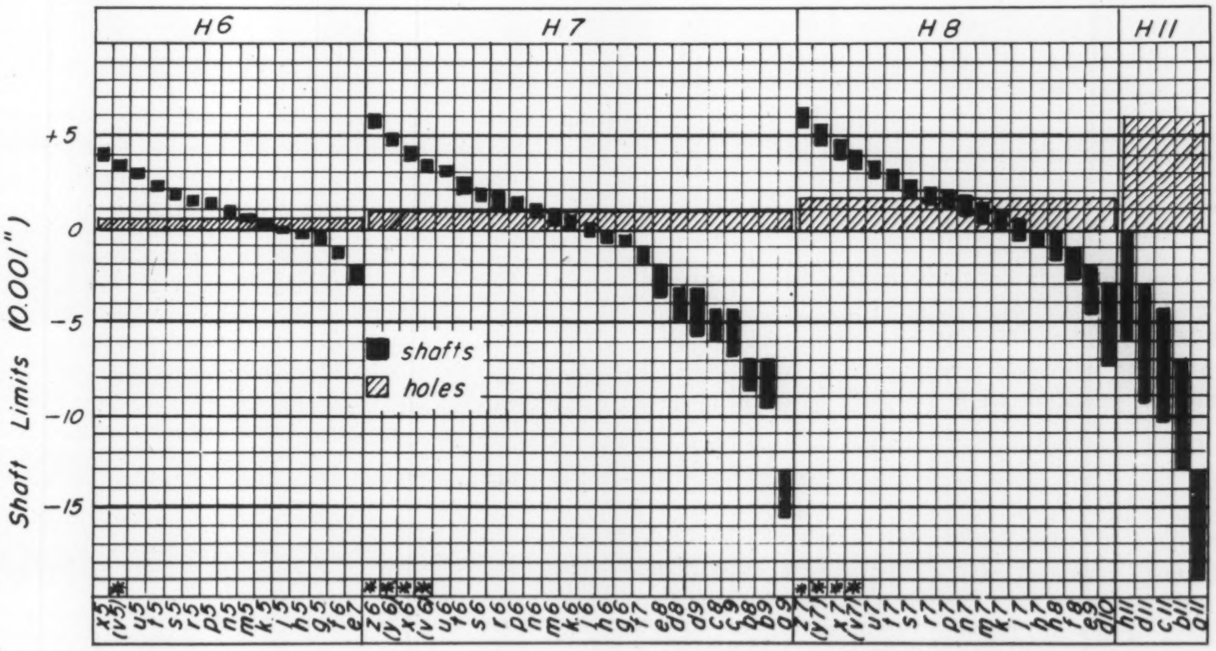
$$i \text{ (mils)} = 0.0520782 \sqrt[3]{D} + 0.001\, D \text{ (inches)}$$

where D is the geometric mean of the diameter steps involved.

The term $0.001\, D$ is introduced, to quote from ISA Bulletin 25, "out of consideration for the uncertainties in measuring with increase in diameter (these being mainly due to differences in temperature and deformation of gauges and working pieces). In practice this is only noticeable in diameters over about 80 mm".

Fundamental tolerances (as rounded off) are given

Fig. 2—Recommend selection of fits for general engineering requirements, represented graphically



** The shafts v, x, y, z are not to be considered as definite recommendations but as recommended for trial. Shafts v and y are to be avoided as much as possible.*

ENGINEERING DATA SHEET

in TABLE I which appears on Page 147.

FUNDAMENTAL LIMITS OR ALLOWANCES: The fundamental tolerances determine the dimensional difference betwen two limits, but to determine the various fits, one of the limits (i.e., the one established by the allowance) must be determined according to some law or formula, the other limit of course being obtained by adding or subtracting the fundamental tolerance. The full schedule of limits is set out in TABLE II (shafts) and TABLE III (holes).

Fundamental limits of the holes *A* to *G* are identical with those of the shafts *a* to *g* but of opposite sign. The unilateral hole is *H, A* being plus and *Z* minus. Conversely the shaft *h* has an upper limit of zero, *a* being minus and *z* plus.

TABLE V—**Interference Fits**

Application	Fit
Precision press fit in steel or iron	n_5/H_6
Normal general-purpose press fit	
In steel or iron	p_6/H_7
In brass or light alloy	s_7/H_8
Heavy press fit	
Min. interference with H_7 hole 0.0063 in. per in.	t*
Min. interference with H_7 hole 0.001 in. per in.	u*
Heavy press or shrink fit	
Min. interference with H_7 hole 0.00125 in. per in. ...	v*
Min. interference with H_7 hole 0.0016 in. per in.	x*
Min. interference with H_7 hole 0.002 in. per in.	y*
Min. interference with H_7 hole 0.0025 in. per in.	z*

---

* Shafts *t* to *z* should be used with discretion.

Disposition of the various shaft limits can be seen in ***Fig.*** 1. Those fits which are considered most useful for normal engineering purposes and thus represent the first step in simplification are illustrated in ***Fig.*** 2. Of the fits represented in this chart, those associated with hole H_6 may be considered extra precision fits as with ball bearings, those with hole H_7 are normal precision while the bulk of quantity-produced parts in the normal production shop could be made to those associated with hole H_8.

TABLE VI—**Transition Fits**

Application	Fit
Light interference fits by selective assembly	*n m*
Ball bearing fits as recommended by bearing manufacturers and where bearings are made to equivalent limits..	*n m k j*
Size and size fit; valve spools; unimportant mating fits; nonrunning fits	*h*

TABLE VII—**Clearance Fits**

Application	Fit
Precision valve spools; very close and delicate working fit	g_5/H_6 g_6/H_7
General-purpose running fit for low speed, even temperature, bearings, pins, shafts, etc.	f_7/H_7 f_8/H_8
Loose running fit	e_8/H_7 e_9/H_8
Fits of appreciable clearance	*d c b a*

Proper interference fits are only obtained with certain qualities of hole and shaft as follows:

Holes	Shafts
H_6..............	n_5 to x_5
H_7..............	p_6 to z_6
H_8..............	s_7 to z_7

Proper clearance fits are only obtained with certain combinations as follows:

Holes	Shafts									
H_6.............	g_5	f_6	e_7							
H_7.............	g_6	f_7	e_8	d_8	d_9	c_8	c_9	b_8	b_9	a_9
H_8.............		f_8	e_9	d_{10}						

Other associations are possible such as a fine hole H_6 with a coarse shaft d_{10}, but for normal purposes such an association would be absurd.

HOLE TOLERANCE SELECTION: For *unilateral holes,* TABLE IV provides a guide to the selection of practical tolerance grades obtainable with present-day production processes.

Oversize holes (*A* to *G*) can be used, with the same tolerance qualities as for the *H* unilateral holes, for those special cases where an oversize hole is desired. ***Example:*** A sliding fit hole on a shaft already made to interference fit limits to suit other holes.

Undersize holes (*J* to *Z*) can be used, with the same tolerance qualities as for the *H* unilateral holes, for those special cases where an undersize hole is desired. ***Example:*** Ball bearing housings to obtain different fits with a bearing made to a standard size.

SHAFT TOLERANCE SELECTION: TABLES V, VI, and VII indicate the shaft tolerance grades and combinations of shaft and hole for interference, transition, and clearance fits.

Wichita City Library

Men OF MACHINES

A. F. Fisher has been elected president of Telechron Inc., Ashland, Mass., to succeed **I. W. Kokins**, who will continue to serve the company in an advisory and consulting capacity. Mr. Fisher joined Telechron in October 1945 as manager of manufacturing and engineering. In April 1946 he was elected vice president in charge of manufacturing and engineering, and became executive vice president of the company's over-all operation in September 1947. Mr. Fisher was graduated from the University of Rochester in 1917. After serving in the U. S. Army he joined the Robeson-Rochester Corporation as plant manager and served in various other management capacities before his election as executive vice president. He was vice president in charge of manufacturing and engineering at Schick Inc., Stamford, Conn., and vice president in charge of manufacturing and engineering for the Northam Warren Corp. in Stamford where he operated the war contracts division of that company prior to joining Telechron.

A. F. Fisher

James L. Myers has been elected president of The Associated Industries of Cleveland. Mr. Myers is president of the Cleveland Graphite Bronze Co., and has been a member of the association's board the past year. He succeeds **W. R. Burwell**, president of the Brush Development Co. Mr. Myers was graduated from Stevens Institute of Technology at Hoboken in 1911, and was successively with the Passaic Metalware Co., the Olds Motor Works at Lansing, Mich., the Northway Motor and Manufacturing Co., Detroit, Coast Coaling Co., New York, and the Barrett Manufacturing Co., Philadelphia. During World War I he was a captain of Army ordnance engineering. In 1919, when Cleveland Graphite Bronze was organized, he was made its chief engineer. He has progressed through the posts of secretary, secretary and treasurer, and executive vice president to the position as the firm's president last year.

James L. Myers

Louis C. Edgar, Jr.

Louis C. Edgar, Jr. has taken over duties as president of the E. W. Bliss Co., builders of stamping presses, can machinery and rolling mills. Mr. Edgar will make his headquarters at the Toledo Works. A mechanical engineering graduate of Cornell, Mr. Edgar was associated with the Babcock & Wilcox Co. in the manufacture of penstocks for the Boulder Dam at Boulder City, Nevada, from 1933 to 1936. From 1936 to 1946 he was with the Blaw-Knox Co. as a service and design engineer and then as general manager of its Martins Ferry Division in Ohio. Since 1946 he has served as president of the H. & B. American Machine Co.

Enrico Volterra of Rome, Italy has been named associate professor of mechanics at Illinois Institute of Technology. Dr. Volterra obtained the degree of civil engineer in 1928 at Rome University and taught mechanics and structures there from 1934 to 1938. He was awarded a Ph.D. degree by Cambridge University where he did research work on structural problems and materials testing at the engineering laboratory.

◆

RUSSEL INWOOD was recently appointed vice president in charge of manufacturing and engineering of the Rapids-Standard Co., Grand Rapids, Michigan. In his new capacity, Mr. Inwood will be responsible for product development and research engineering, and all manufacturing activities.

◆

ROBERT M. ARNOLD recently was made a vice president of Allegheny Ludlum Steel Corp., Pittsburgh. Mr. Arnold is also president of Arnold Engineering Co. of Chicago, a wholly owned subsidiary. Educated at the Massachusetts Institute of Technology, he has served as a director of Allegheny Ludlum since September 1946, and as president of Arnold Engineering since 1941. In 1922 he was employed by a Chicago firm of consulting engineers dealing in electronics and later served as chief engineer for several radio manufacturers in this country and in England.

◆

EMANUEL MAXWELL, previously a faculty member of Massachusetts Institute of Technology, has joined the National Bureau of Standards where he will be concerned with low-temperature physics and superconductivity in the Cryogenics section of the heat and power division.

◆

PAUL T. PETERSON has accepted the position of chief engineer in charge of design and manufacturing of the Dalzen Tool and Manufacturing Co., Detroit, manufacturers of broaching equipment.

◆

WILLIAM E. SHOUPP, distinguished nuclear physicist, was named director of research for Westinghouse Electric Corp.'s new atomic power division, and ROBERT A. BOWMAN was appointed manager of engineering. Both men will help guide the division's activities which will include the construction and testing of an atomic power plant for the propulsion of naval vessels.

◆

CARL F. KAYAN has recently been appointed head of the department of mechanical engineering at Columbia University's school of engineering. He had been in charge of the administration of graduate work in the mechanical engineering department.

◆

J. R. DEDRICK, formerly associate professor of powder metallurgy at the University of Cincinnati, has been appointed section head of the advanced development group at the metallurgical research laboratories of Sylvania Electric Products Inc. Dr. Dedrick will have charge of the group doing work of a research nature on commercial products such as the application of powdered metals to the improvement of lamp and radio tube filaments, cathode materials for television and electron tubes, fluorescent lamps and other commercial products requiring tungsten and alloy wires. His undergraduate work was at Pennsylvania State College and he obtained his Doctor's degree from the Massachusetts Institute of Technology.

◆

FRANK G. HOOVER was recently elected president of the Hoover Co., North Canton, Ohio. Mr. Hoover joined the firm in 1903. In 1922 he became vice president and assistant general manager and continued in that capacity until his recent election as president. He succeeds his elder brother, H. W. HOOVER, who will become chairman of the board.

◆

WILLIAM LEE DAVIDSON has been named director of the B. F. Goodrich Co.'s physical research department.

◆

CHARLES E. BALLEISEN, research engineer in mechanical engineering, has been appointed to the staff of Southwest Research Institute. Mr. Balleisen, whose special fields are ordnance, astronomy and automatic mechanisms, obtained his master's degree at Massachusetts Institute of Technology. Mr. Balleisen has contributed several articles to MACHINE DESIGN, the latest one appearing in the June 1948 issue.

◆

C. A. SCHARSCHU, director of research of Allegheny Ludlum Steel Corp. has been appointed assistant technical director. Mr. Scharschu, a graduate of Cornell University, has been associated with Allegheny Ludlum since 1929 when he joined the former Allegheny Steel Co. as chief metallurgist and director of research. He was previously employed by General Electric Co. Mr. Scharschu is a member and serves on various technical committees of the American Institute of Mining and Metallurgical Engineers and the American Iron and Steel Institute. He also is a member of the British Iron and Steel Institute. L. C. HICKS, associate director of research, will fill Mr. Scharschu's former position.

◆

B. H. ALEXANDER, formerly professor of metallurgy at the Carnegie Institute of Technology, has joined the staff of the metallurgical research laboratories of Sylvania Electric Products Inc.

◆

ALLEN E. PUCKETT, chief, wind tunnel section, jet propulsion laboratory, California Institute of Technology, has been chosen by the Institute of the Aeronautical Sciences as the 1948 Lawrence Sperry Award winner. CLARK B. MILLIKAN, acting director of the Guggenheim Aeronautical Laboratory, California Institute of Technology, and acting chairman of the jet propulsion laboratory, has been elected 1948 American honorary fellow of the Institute of the Aeronautical Sciences.

new parts and materials

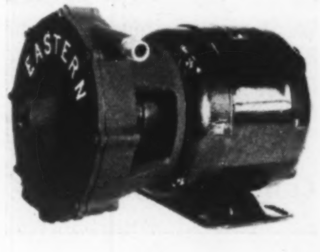
For additional information on these new developments see Page 251

Wedge-Locking Shaft Coupling

Utilizing the Taper-Lock bushing as a fastening device, new rigid coupling may readily be applied to shafts without the use of special tools. Bushing is locked by means of two screws which pull mating elements together into the equivalent of a press fit. Drive, however, is effected through a key. Couplings are made in shaft sizes from $\frac{1}{2}$ to 5 inches and entirely replace the old type Dodge couplings in sizes up to and including 2 15/16 inches. Manufacturer: Dodge Mfg. Co., Mishawaka, Ind.

For additional information circle MD 1 on Page 251

Centrifugal Pump



Model H centrifugal pump is designed specifically for applications requiring moderate pressures and volumes at 1725 rpm. The pump has a shutoff pressure of 19 psi, and delivers 10 gpm at 15 psi, 15 gpm at 10 psi and over 20 gpm at free flow. Construction is bronze or aluminum with mechanical rotary seal. Inlet is $\frac{1}{2}$-inch, female NPT and outlet is $\frac{3}{8}$-inch male NPT; drain plug is provided. Units are made with motors ranging from 1/6 to 1/3-hp depending on the operating range. With the smaller motor, the overall size is $12\frac{1}{8}$ inches long, $7\frac{3}{8}$ inches high and 8 3/16 inches wide. Weight of bronze unit is 37 pounds. Manufacturer: Eastern Industries Inc., 296 Elm St., New Haven 6, Conn.

For additional information circle MD 2 on Page 251

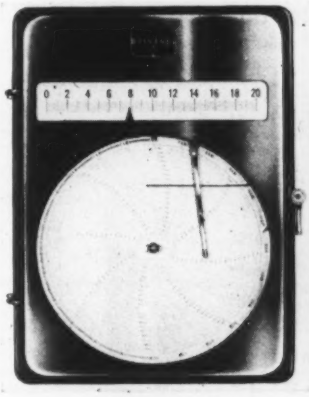
Vibration-Mount Material

New anti-vibration material tradenamed Elasto-Rib consists of a layer of cork bonded between two layers of deep-grooved, oil-resistant, synthetic rubber. The ribbed contour of the material provides high deflection and forms a nonskid contact between the mounting surfaces. Elasto-Rib is made in 1-inch sheets up to 24 by 36 inches in size. Recommended loading is between 7 and 21 psi. Manufacturer: Korfund Co. Inc., 48-15 32nd Place, Long Island City 1, N. Y.

For additional information circle MD 3 on Page 251

Operating-Time Recorder

Giving a direct, uniform scale reading of time consumed for travel of a part through a process, new recording instrument eliminates need of converting units as is required of conventional work-travel recorders. These time-in-process recorders can be used on such equipment as continuous drying ovens and other continuous process systems. Manufacturer: The Bristol Co., Waterbury 91, Conn.



For additional information circle MD 4 on Page 251

Magnetic Contactors

Suitable for use in motor, heater and lamp controls, the new Bulletin 4454 size 4, and Bulletin 4455 size 5 contactors are rated 150 and 300 amperes, respectively, when operating on alternating current. Size 4 contactors are made with a maximum of 5 main poles and size 5 units with 2 or 3 poles. Both sizes can be supplied with open type construction or with NEMA type I enclosures. Coils are obtainable for operation on 110, 220, 440 and 550 volts with frequencies of 25, 50 or 60 cycles. Features include interchangeable contacts, accessible clamp type connectors, standardized mounting panels and removable arc shields. Manufacturer: Ward Leonard Electric Co., Mount Vernon, N. Y.

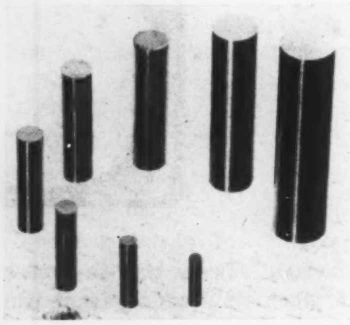
For additional information circle MD 5 on Page 251

Magnetic Starter

Size 1, type RA magnetic starter is said to be the smallest starter available. Suitable for use with 5-hp 220-volt and 7½-hp 550-volt motors the unit has an enclosure measuring $6\,^{3}/_{16}$ by $6^{11}/_{16}$ inches. Features include vibration and shock resistance, separate contact compartments and uniform contact pressure. Both starters and contactors use the same box and have interchangeable parts. Manufacturer: Arrow-Hart & Hegeman Electric Co., 103 Hawthorn St., Hartford 6, Conn.

For additional information circle MD 6 on Page 251

Solid Carbide Cylinders



Line of cemented-carbide cylinders are made in both ground and unground types. Sizes range from 3/32 to ½-inch diameter in lengths ranging from 3/16 to 1½ inches. Diameters from 3/32 to ¼-inch are in steps of 1/32-inch, while diameters from ¼ to ⅜-inch are in steps of 1/16-inch. All lengths are in steps of 1/16-inch. Rods are available in Carboloy grades 44A, 55A, 78, 78B, 883, 905 and 999. Manufacturer: Carboloy Co. Inc., Detroit.

For additional information circle MD 7 on Page 251

Overload Detecting Device

Recommended for use in warning of overloads, magnetic strain gage measures small distortions resulting from loading in tension or compression. Unit consists of gage protected by a water-tight case measuring 3½ by 8¼ by 3¼ inches, and a pilot bar sensitive to a force as small as 20 pounds. Device is mounted rigidly upon the structural member being protected and an indicating dial can be remotely located. Operation is on single-phase 110-volt, 60-cycle current. Power requirement is 35 volt-amperes. Manufacturer: Westinghouse Electric Corp., P.O. Box 868, Pittsburgh 30.

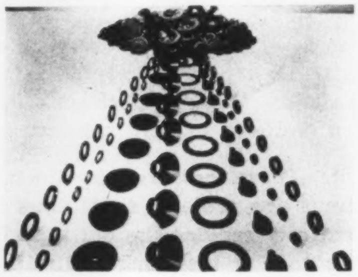
For additional information circle MD 8 on Page 251

Low-Temperature Grease

Lime-base grease known as H Grease O, is soft in consistency and is intended for use in winter lubrication. It is the latest addition to the H series of greases designed for general purpose industrial applications requiring higher viscosity mineral oils than found in conventional cup greases. Manufacturer: The Texas Co., 135 E. 42nd St., New York.

For additional information circle MD 9 on Page 251

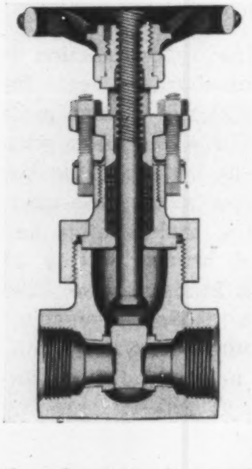
Solvent-Resistant Rubbers



Synthetic rubber compounds are resistant to the solvent action of petroleum products, their derivatives and other industrial lubricants. These compounds of Buna N, Hycar and Neoprene can be fabricated into gaskets, sleeves, washers, molded products and extruded sections. They can be formulated with tensile strengths from 500 to 2500 psi, having Durometer hardnesses of 40 to 90 and elongations from 100 to 600 per cent. In addition, they can be modified to fit the various SAE specifications. Manufacturer: Stalwart Rubber Co., 180 Northfield Rd., Bedford, Ohio.

For additional information circle MD 10 on Page 251

Cast-Steel Gate Valves

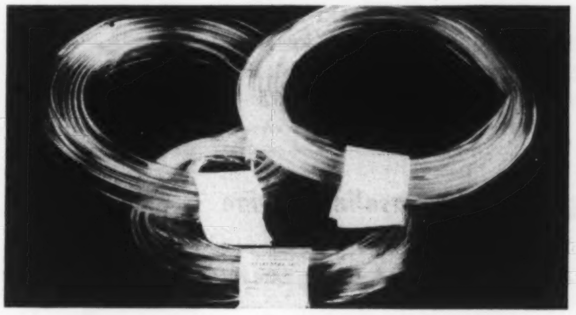


Line of compact, cast-steel gate valves are rated 600 psi. Of the union bonnet type, they are available in sizes through 2 inches. No. 3602XW has Exelloy seats and hardened stainless-steel disk; No. 3602X has seats and disk of Exelloy. In sizes ¾-inch through 2 inches the bonnet ring, bonnet and yoke are separate parts; from ¼ through ½-inch, these parts are cast as one piece. The joint between the body and the bonnet is sealed with a soft iron gasket which is not affected by high temperatures or by fluids for which the valve is recommended. Type XW units are suitable for use with water, super-heated steam, hydraulic oils, gasoline, etc. Type X valves are recommended for oil and oil vapor at temperatures up to 1000 F but are not recommended for use with steam or other nonlubricating fluids. Replaced by this series are the No. 3606XW and 3606X valves. Manufacturer: Crane Co., 836 S. Michigan Ave., Chicago 5.

For additional information circle MD 11 on Page 251

Plastic Electrical-Insulating Tubing

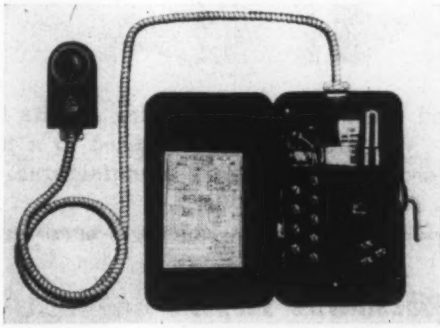
Lightweight vinyl tubing known as Insulite is suitable for use in consolidating a bundle of conductors into a compact, insulated cable. The tubing has a dielectric strength of 800 vpm at 20,000 volts per 0.025-inch, is temperature resistant and has a water absorption of 0.32 per cent after 10 days test. Tensile strength is 2930 psi. Manufacturer: Extruders Inc., 8509 Higuera St., Culver City, Calif.



For additional information circle MD 12 on Page 251

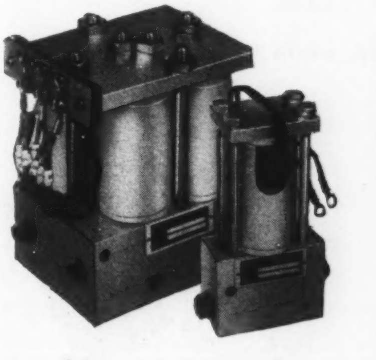
Photoelectric Control

Type 20DJ1 photoelectric control, designed for general industrial application, is suitable for use in counting, signal systems, motor control and stop-motion control. It has an operating range of 10 feet, and functions in 1/20-second. Phototube is available either integral with the housing or in a separate case. This control operates on 60-cycle power and is rated 10 amperes at 115 volts or 5 amperes at 230-volts. Sensitivity adjustment permits operation at any predetermined level of illumination within the range of 10 to 50 foot-candles. Manufacturer: Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.



For additional information circle MD 13 on Page 251

High-Pressure Solenoid Valves

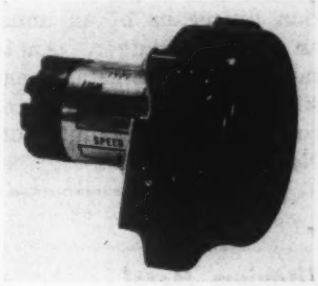


Line of 3000-psi hydraulic solenoid valves are made in two, three and four-way types either normally open or normally closed. Operating on 6 to 36 volts dc, the valves have low current consumption. Dimensions are 4 by 3 by 5¾ inches high. Manufacturer: Waterman Engineering Co., 721 Custer Ave., Evanston, Ill.

For additional information circle MD 14 on Page 251

Electric Blower Unit

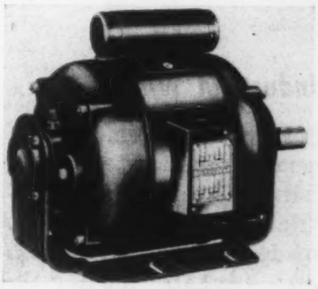
Moto-Mite blower unit will produce 20 cfm of air at an outlet velocity of 3270 fpm. The unit operates at 11,000 rpm and consumes 14.5 watts through a $^{1}/_{100}$-hp dc motor driving a centrifugal impeller. Motor diameter is $1\,^{3}/_{16}$ inches, and frame is 1¾ inches long. Maximum diameter of impeller casing is 2⅜ inches. Units are available for operation on 6, 12 or 24 volts, dc. Manufacturer: Globe Industries Inc., 425 Sunrise Place, Dayton 7, Ohio.



For additional information circle MD 15 on Page 251

Fractional Horsepower Motors

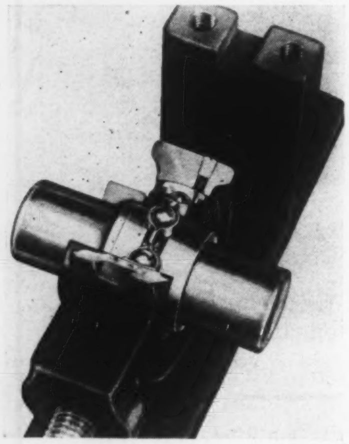
Line of resilient and rigid-base motors are available in ratings of ¼, $^{1}/_{3}$ and ½ hp. They are single-phase, 1725-rpm, dual-voltage, capacitor-start units available with either sleeve or ball bearings. The rubber-mounted units are designed for quiet operation and long life, and the entire line of motors are sturdily constructed for heavy-duty service. Sleeve bearing motors have accurately ma-



chined wool-packed bearings fitted with oil reservoirs and oil return grooves. Ball-bearing units are prelubricated and sealed against dirt. Manufacturer: The Hoover Co., Kingston-Conley Div., North Plainfield, N. J.

For additional information circle MD 16 on Page 251

Ball-Bearing Take-Up Units



Facilitating shaft adjustment and belt tightening, Type LTU take-up units are made in shaft sizes from ¾ to 2 7/16 inches. Units incorporate prelubricated self-aligning wide inner ring ball bearings with self-locking collars and frictionless oil seals. The special seal construction, known as Mechani-Seal, provides effective operation by means of an unusually long labyrinth, plus an external slinger. An inner steel plate shield attached to the bearing's outer ring retains lubricant, while a slinger attached to the inner ring throws off contaminants. Manufacturer: Fafnir Bearing Co., New Britain, Conn.

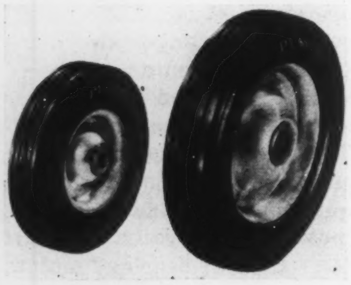
For additional information circle MD 17 on Page 251

Titanium Metal

Available commercially for the first time, 99.5 per cent pure titanium is now being produced. The material is comparable to stainless steel in strength and corrosion resistance and has about half the weight. Melting point is higher than that of the commonly used metals. Suggested applications include engine parts where heat and pressure are great. Manufacturer: E. I. du Pont de Nemours and Co. Inc., Wilmington, Del.

For additional information circle MD 18 on Page 251

Industrial Wheels



Line of Pemco semipneumatic or hard rubber industrial wheels are made in two models: 8x1.75 and 6x1.5. The larger wheel is 8 inches in diameter, has 1⅞ inch hub and either ½ or ⅝-inch arbor hole. Both 125 and 300 pound load ratings are made. The 6-inch wheel has a 1¾ inch hub and either ½ or ⅝-inch arbor, and is made in the same load ratings as the larger model. Units feature use of 18-gage metal, and oilless bearings. Manufacturer: Paramount Engineering and Mfg. Co., 1873 Ravine Rd., Kalamazoo, Mich.

For additional information circle MD 19 on Page 251

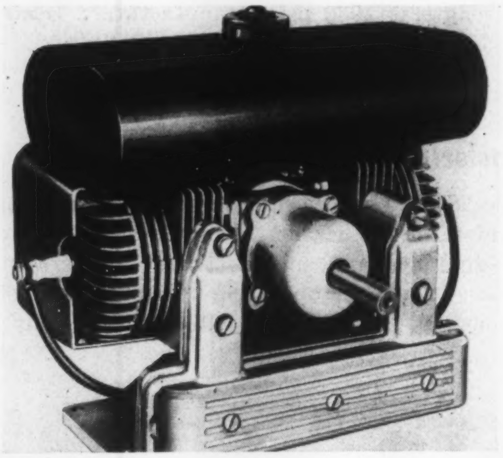
Leakproof Pipe Plugs

Dryseal nonleaking pipe threads are used on line of pipe plugs up to 1 inch in size. These new standard threads are designed to function without the use of sealant compounds of any type, metal-to-metal contact being accomplished by truncation of the root of male and female threads. Plug sizes for which this thread is available are ⅛, ¼, ⅜, ½, ¾, and 1 inch. Manufacturer: U. S. Pipe & Fitting Co., 305 Frederick Bldg., Cleveland 15.

For additional information circle MD 20 on Page 251

Light-Weight Gasoline Engine

Compact, air-cooled engine rated at 2 hp weighs 23 pounds, and is said to be one of the lightest engines of this capacity ever developed. Measuring 11½ by 13½ by 14½ inches, this model 3000 engine is suited for use with portable equipment. The engine starts easily and operates without stalling at tilts up to 45 degrees. Vibration has been reduced to a minimum by opposed piston design. Manufacturer: Power Products Corp., Grafton, Wis.



For additional information circle MD 21 on Page 251

Metal Ribbon-Wire Shapes

Precise metal ribbons for use as electronic and instrument components are made in a range of shapes and alloys. These rolled or drawn ribbons are available in nickeled steel, stainless steel, copper-clad steel, Inconel, copper, beryllium copper, phosphor bronze, brass, and aluminum. Sections measure up to

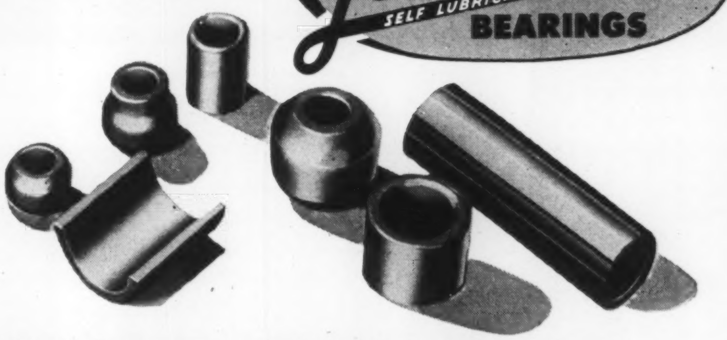
JOHNSON BRONZE

SLEEVE BEARING DATA

Ledaloyl SELF LUBRICATING BEARINGS

JOHNSON BRONZE

SLEEVE BEARING DATA



POWDER METALLURGY for Bearings and Parts

Powder Metallurgy is not a new manufacturing process . . . but its wide-spread adoption by industry is of comparatively recent origin. Bearings and parts, when produced by this method, are molded under pressure to required shape and size. This eliminates expensive machining operations and when quantities of a size are used the cost is surprisingly low. The original formula of the bronze powder consisted of approximately 88½ copper, 10 tin and 1½ graphite. In 1936, Johnson Bronze introduced LEDALOYL . . . a powder metallurgical product that conbined copper, tin, graphite and *LEAD* in the form of a PRE-ALLOYED bearing bronze. The introduction of lead as an integral part of the bronze powder provided additional bearing qualities not possible otherwise.

Manufacturers of many types of equipment gain many extra advantages through the use of Johnson LEDALOYL. One valuable feature is the self-lubricating action. Myriads of tiny, evenly spaced pores serve as miniature oil wells. When the bearing is in use the oil is metered to the shaft . . . when at rest, the oil is absorbed by these pores. This provides adequate lubrication at all times . . . preventing wear and in most cases eliminating the expense and bulk of other lubrication aids. Service records show long, troublefree operation on many types of installations.

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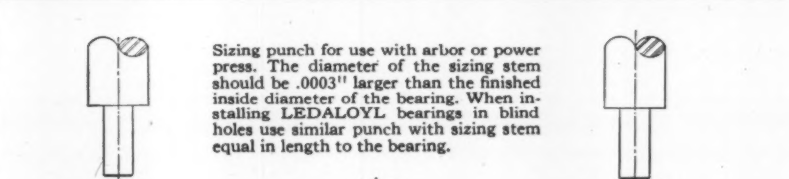
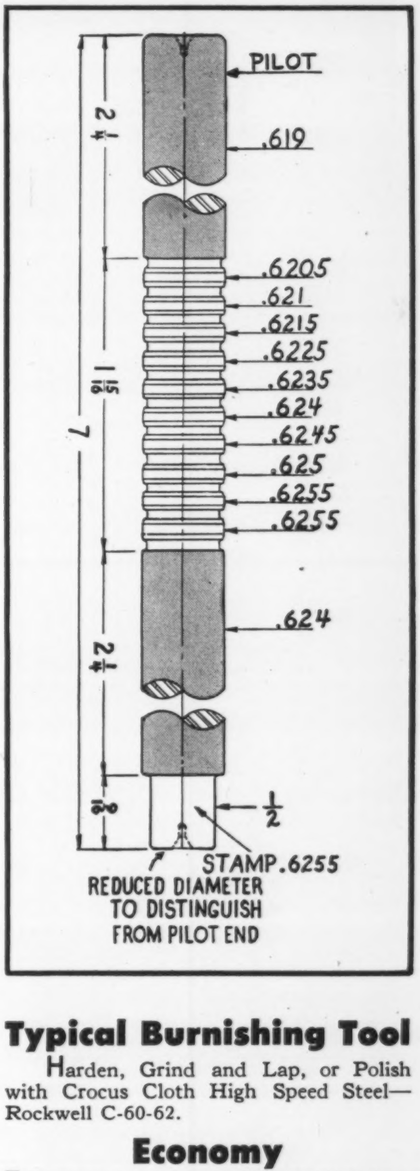


Sizing punch for use with arbor or power press. The diameter of the sizing stem should be .0003'' larger than the finished inside diameter of the bearing. When installing LEDALOYL bearings in blind holes use similar punch with sizing stem equal in length to the bearing.

Method of Installations

LEDALOYL Bearings, correctly designed and properly installed, will usually outlast the motive unit in which they are used. We cannot place too much emphasis on installation. Absolute alignment is necessary in order to gain a low operating temperature, a short running-in period and a conservation of lubricant. The usual method of installing LEDALOYL is illustrated above. If your application is not covered in this way, we ask that you consult with our engineers. A method suitable to your application will be worked out. If your bearings are subject to excessive temperature during installation—such as in die cast applications—it is usually advisable to withhold impregnating the bearing until after assembly.



Typical Burnishing Tool

Harden, Grind and Lap, or Polish with Crocus Cloth High Speed Steel—Rockwell C-60-62.

Economy

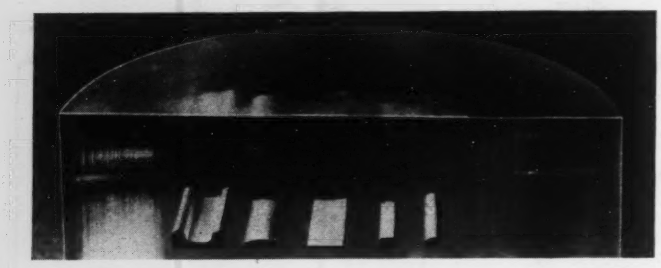
The economy of using LEDALOYL is best illustrated in producing parts other than cylindrical in shape. Flat surfaces—flanges, offsets, etc. are easily provided for in the dies and no additional machining is necessary. Johnson engineers are always available to discuss the advisability of using LEDALOYL . . . or any other type of sleeve bearing in your product. Your inquiry carries no obligation.

●

This bearing data sheet is but one of a series. You can get the complete set by writing to—

Johnson Bronze

SLEEVE BEARING HEADQUARTERS
525 S. MILL ST. • NEW CASTLE, PENNA.



$\frac{1}{8}$-inch in width and include channels, squares, rectangular shapes, $\frac{1}{4}$-rounds, $\frac{1}{2}$-rounds and flats. They are made in a wide range of thicknesses and special shapes. Manufacturer: Sylvania Electric Products Inc., Emporium, Pa.

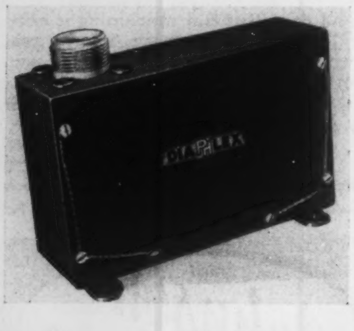
For additional information circle MD 22 on Page 251

Synchronous Differential

Used in synchronizing engines, etc., the synchronous differential is, in effect, a torque-producing half-speed synchroscope. Unit consists of two synchronous motors and a mechanical differential mounted in a single housing measuring 3 45/64-inches long and $2\frac{3}{8}$ inches in diameter. Each of the two motors reflects the operating speed of an engine and, in turn, activates a $\frac{1}{4}$-inch output shaft through the differential. Output shaft rotates at a rate equal to one-half the difference between the speeds of the two motors. When engines speeds are equalized the motors rotate at the same speed and the output shaft becomes stationary. Differentials operate from a three-phase source over a frequency range of 15 to 60 cycles with an input voltage of 0.007 times the frequency in cycles per minute. Other units are available for operation on higher voltages and one or two-phase current. Manufacturer: Kollsman Instrument Div., Square D Co., 80-08 45th Ave., Elmhurst, N. Y.

For additional information circle MD 23 on Page 251

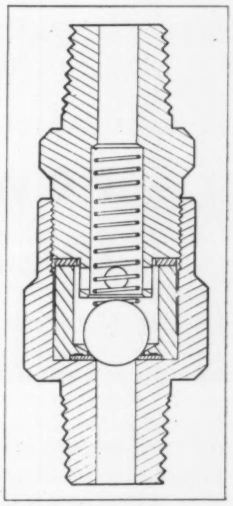
Pressure-Actuated Switches



Pressure - actuated switches are available in the sensitivity range of 0.1-inch of water to 30 psi. Identified as Hy-G switches, the units will withstand 20*g* of vibration as well as high surge pressures. Compact, they measure $4\frac{3}{4}$ by $2\frac{5}{8}$ by 1 9/16 inches and weigh 11 ounces. Features include stability through temperature range of −60 to +160 F. Contact arrangements include single-pole single-throw or single-pole double-throw, double make or break. Standard unit is rated 28 volts dc, other voltages can be handled by use of accessory relays. Manufacturer: DiaPhlex division of Cook Electric Co., 2700 Southport Ave., Chicago 14.

For additional information circle MD 24 on Page 251

High-Pressure Check Valves



Suitable for use as pump inlet and outlet valves in dispensing machines, new check valves will prevent flow reversal when passing gases into solution. They are also recommended for the usual single-fluid applications. Feature of the new units is the use of a soft nonextruding plastic valve seat which will withstand back pressures in excess of 1000 psi, yet seal at very low pressure differentials. Valve bodies are brass, with other materials available on specification. Manufacturer: Hoke Inc., Englewood, N. J.

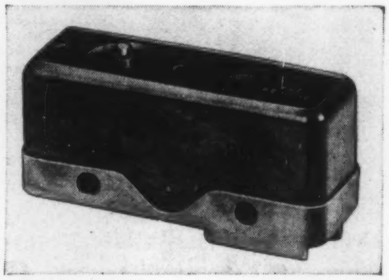
For additional information circle MD 25 on Page 251

Nonconducting Magnetic Materials

Magnetic materials known as Ferroxcube have high permeabilities as well as low remanence and coercivity, yet are nonconducting. Owing to these properties the materials permit reduction in apparatus size. Manufacturer: North American Phillips Co. Inc., 100 E 42nd St., New York 17.

For additional information circle MD 26 on Page 251

Universal Type Snap Switch



Rated 10 amperes at 125 volts, the Model DMX switch may be used at this rating on either ac or dc circuits. The switch measures $1\frac{15}{16}$ inches long, $\frac{11}{16}$-inch wide and $\frac{61}{64}$-inch deep and mounts on one-inch centers. A focused-flux Alnico magnet positioned in the housing blows out arcs as soon as the contacts open, while a ceramic baffle chamber keeps the arc from reaching the contact supporting screws. Arc-resistant melamine plastic is used for the base and cover. To permit varied methods of applying operating force the type DMX switch is provided with a recessed cover which accepts adapter plates. The type Y or F prestressed, hinged adapter plate provides for normally-closed, single-pole, single-throw contact ar-

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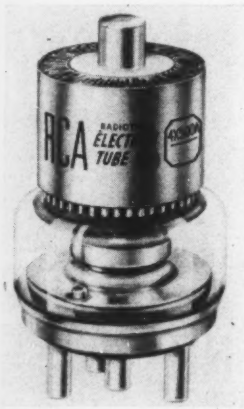
rangement; with other plates or the basic switch the contacts are normally open. Manuafacturer: Unimax Switch Div., W. L. Maxson Corp., 460 W. 34th St., New York 1.

For additional information circle MD 27 on Page 251

Air-Cooled Power Tetrode



Type RCA-4X500A power tetrode is a filament type, radiator-cooled, four-electrode tube suitable for use as a radio-frequency amplifier and oscillator. It has a maximum plate dissipation of 500 watts and can be operated at full rating up to 120 megacycles. Filament voltage is 5 volts, current drain 13.5 amperes. Tube is mounted in vertical position and measures 4¾ inches long and 2⅝ inches in diameter. Unit features low-inductance leads, low grid-plate capacitance, effective shielding between grid and plate circuits and grid terminal located at center of filament end of tube to facilitate its use in coaxial circuits. Manufacturer: Radio Corp. of America, Harrison, N. J.

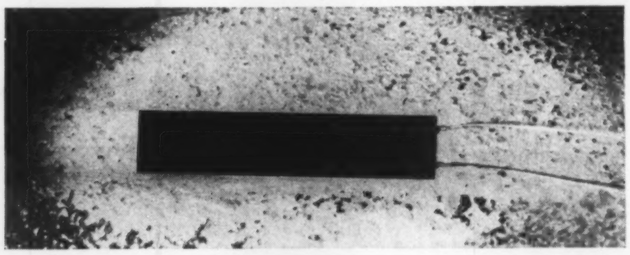
For additional information circle MD 28 on Page 251

Spring-Driven Stepping Switches

Up to 260 contacts can be provided on new high-speed, spring-driven stepping switches. Made in sizes having from one to ten banks, the switches have 26 contacts on each bank, a pair of double-ended wiper springs being stepped over each bank level. Bank occupies 180 degrees of arc, therefore as one end of wiper leaves one end of bank, other end of wiper engages first contact at other bank end. Stepping magnet may be controlled remotely or wipers may be caused to step automatically by interruption of circuit by springs mounted on switch. Suitable for operation on direct current only, the switch measures 6 $^9/_{16}$ inches long, 2⅜ inches wide and 4⅝ inches in height. Manufacturer: C.P. Clare & Co., Chicago.

For additional information circle MD 29 on Page 251

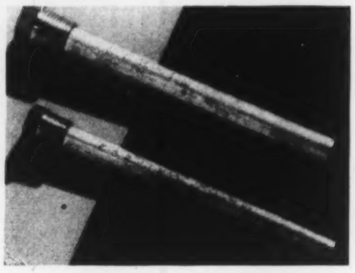
Thermometer Element



Thermometer element consisting of a nickel wire resistance bonded into a thin Bakelite wafer may be cemented to any type of surface for temperature measurement. Known as the RdF Stikon, the element fits the curve of resistance change versus temperature as defined by Army-Navy aeronautical specifications for electrical resistance thermometers, and will operate in conjunction with standard indicators recorders and controllers made to fit this curve. The measuring devices operate with full accuracy in continuous service from −40 to 400 F and give months of service at 350 F. Exact deviation of each element from standard is given for 70 F. Manufacturer: Ruge-de Forrest, 76 Massachusetts Ave., Cambridge 39, Mass.

For additional information circle MD 30 on Page 251

Corrosion-Inhibiting Rods



Corrosion-inhibiting rods, tradenamed Cor-In, are fitted with standard pipe-plug ends for use in hydraulic systems. These zinc rods come in ⅜, ½, ⅝, ¾ and 1-inch diameters with lengths up to 12 inches. They have a higher electrochemical potential than the metals to be protected, thus they are consumed rather than the metals of the systems in which they are used. In addition to preventing extreme corrosion, the rods can be used to extend life of any system which experiences slight degrees of corrosion. Manufacturer: Rotometals Inc., 980 Harrison St., San Francisco 7.

For additional information circle MD 31 on Page 251

Shock-Resistant Hydraulic Gage

Hydraulic dial gage designed for heavy service will withstand surging and pounding hydraulic pressures. Gage is made in 9 pressure ranges, the lowest of which is 5-50 psi, the maximum is 500-5000 psi. Instrument has white dial face with black numerals. Crystal is a shatter-proof plastic. Manufacturer: A. Schrader's Son, Div., Scovill Mfg. Co. Inc., 470 Vanderbilt Ave., Brooklyn 17, N. Y.

For additional information circle MD 32 on Page 251

Photoelectric Counter

Multipurpose photoelectric counter, type 20AP5, is a complete unit consisting of light source, photoelectric control and electronic counter. Light and counter are supplied with cords and plugs which

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"DOUBLE-ZERO" BEARING IS A "GENERATED UNIT ASSEMBLY"

To achieve the extreme accuracy of the "Double-Zero" bearing, Timken engineers built specialized machine tools, developed measuring devices of extreme accuracy, and perfected new manufacturing processes.

Then, to assure positive roll alignment, long lasting precision, permanent adjustment, and smoother operation, the "Double-Zero" bearing goes through an extra step in manufacture. A natural and true geometric contact is generated between all rotating parts, which results in a "Generated Unit Assembly".

The new "Double-Zero" bearing is the latest example of Timken leadership in serving the bearing needs of all industry. Whenever you buy bearings, it pays to look for the trade-mark "Timken". The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

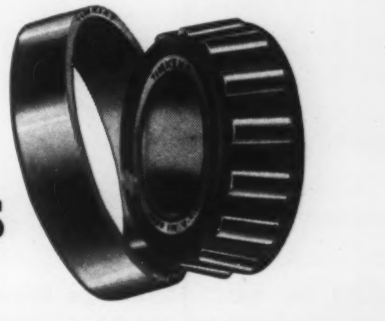
A PRECISION TIMKEN BEARING FOR EVERY REQUIREMENT

CLASS	**"OO" (DOUBLE-ZERO)**	**"O" (ZERO)**	**"3" (THREE)**
RUN-OUT	.000075″	.000150″	.000300″
TYPES AVAILABLE	Standard Single Row	Standard Single Row	All types
SIZE RANGE	Up to 10″ O.D.	Up to 12″ O.D.	Up to 12″ O.D.

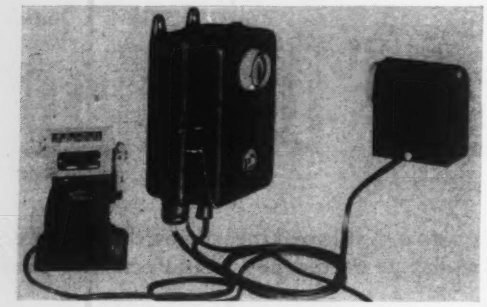
TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS



NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL AND THRUST LOADS OR ANY COMBINATION attach to the photoelectric control. Light source has adjustable lens system which permits narrowing down the light beam for counting very small objects. Operating from a 115-volt power source the counter has an operating speed of up to 600 counts per minute and an operating range of 6 feet between photoelectric unit and light source. Maximum number of counts before returning to zero is 100,000. Feature of the unit is the simplicity with which remote counting can be done. Manufacturer: Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.



For additional information circle MD 33 on Page 251

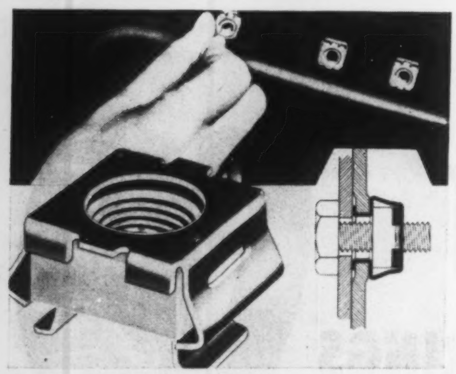
Electrical Contact Material

Desirable properties of silver plus resistance to sticking and welding are provided by Fasaloy 99 electrical contact alloy. The material is obtainable in the form of rivets, screws, buttons, disks and special shapes. Manufacturer: Fansteel Metallurgical Corp., North Chicago, Ill.

For additional information circle MD 34 on Page 251

Nut Retainer

Fastening device called the Speed Grip nut retainer holds standard square nuts to sheet metal panels. Unit is a stamping which forms a cage around the nut. Metal lips engage square hole in metal panel and require no tool for application. Need of a wrench for tightening bolt in place is eliminated. Because the nut floats within retainer, slight misalignment in assembly is permissible. Manufacturer: Tinnerman Products Inc., 2038 Fulton Rd., Cleveland 13.



For additional information circle MD 35 on Page 251

Flow-Control Valve

Model FC flow-control valve is designed for accurate automatic control of cylinder speed without affecting the power of the cylinder. The valve is positioned in the line between the operating valve and the cylinder to control the speed of air being exhausted from the cylinder. For control of piston speed in both directions a valve must be placed in the lines going to each end of the cylinder. Adjustment of the unit is by a valve screw which positions a floating bevel-seat poppet. Valve body is naval bronze, working parts are stainless steel. Seat and O-ring packing are oil-resistant rubber. Six standard sizes are ¼, ⅜, ½, ¾, 1 and 1¼ inches. Rating is 1000 psi. Manufacturer: Airmatic Valve Inc., 1643 E. 40th St., Cleveland.

FC-500
CYL
VAL
AIRMATIC VALVE INC

For additional information circle MD 36 on Page 251

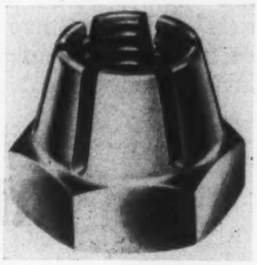
Cast-Aluminum Industrial Wheels

Split type industrial wheels of aluminum construction are designed for use with zero-pressure, solid rubber and pneumatic industrial tires. The units can be furnished with bearings or be machined to special bearing mount specification. Standard sizes include: 6 by 2.00, 8 by 2.50, 10 by 2.50, 10 by 2.75, 12 by 3.00, 16 by 4.00 and 4.00 by 8. Manufacturer: Pikes Peak Aluminum Foundry Inc., Colorado Springs, Colo.

For additional information circle MD 37 on Page 251

High-Temperature Locking Fastener

Vibration-resistant locking fasteners are suitable for use at temperatures ranging from −65 to +1200 F. They are made in two types: Z-1200, for use to 1200 F and ZE for use at temperatures to 550 F. The nuts hold by means of springs formed into them, enabling them to hold at any position on the bolt. Both series are available in hex and anchor types. The ZE line is made in five thread sizes ranging from 10-32 to



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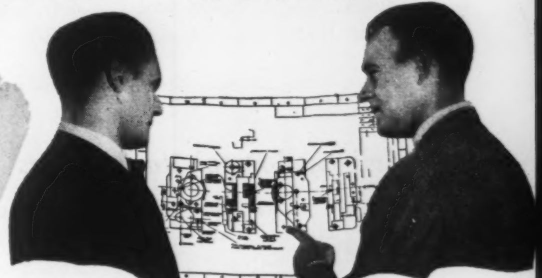

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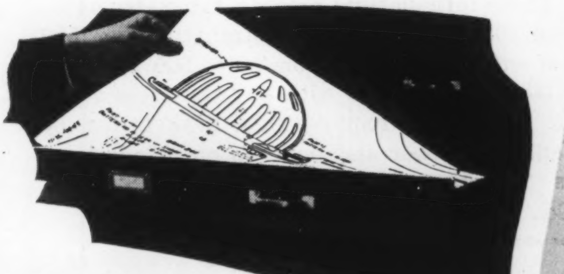

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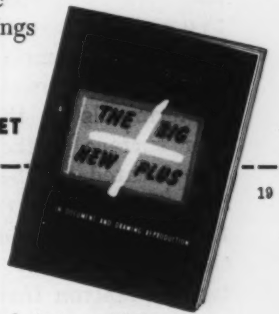

19

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the fractional size of $\frac{3}{8}$-24, with the 8-32 also available in the hex nut. Series Z-1200 nuts are made in four sizes ranging from 10-32 to $\frac{3}{8}$-24 while the anchor nuts of this series are available in three sizes: 10-32, $\frac{1}{4}$-28 and $\frac{5}{16}$-24. Manufacturer: Elastic Stop Nut Corp., of America, 2330 Vauxhill Rd., Union, N. J.

For additional information circle MD 38 on Page 251

Embossed-Metal Name Plates

Embossed name plates of aluminum, zinc, brass and stainless steel, etc., are made in a range of lettering and numeral sizes. The units feature high legibility and low cost, they will withstand rough usage and are difficult to mar. Fastening of the plates can be by soldering or welding, or holes may be provided for fastening by screws or rivets. Manufacturer: Chicago Car Seal Co., 634 N. Western Ave., Chicago 12.

REFRIGERATOR SERIAL PLATE
MODEL NO.
SERIAL NO.
STYLE
MANUFACTURED BY
PHILCO CORPORATION
PHILADELPHIA, PA.
MADE IN U.S. OF AMER.

For additional information circle MD 39 on Page 251

Tachometer Indicator

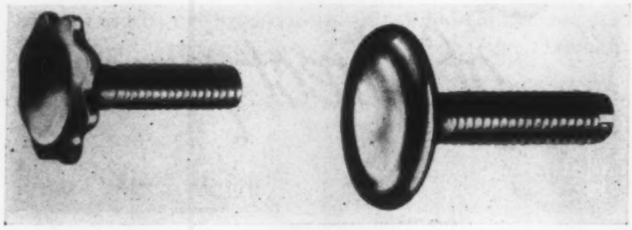
Type 43 single-range tachometer indicator is designed to provide flush switchboard mounting from front or rear or by means of bottom bracket. Electrical connections from any Metron tachometer head can be made to terminals on the rear surface of the indicator. Calibration control is also located on the rear of the instrument. Speeds from 1 to 100,000 rpm are indicated on a 4-inch scale. Large numerals and heavy calibration markings make the indicator easy to read at a distance. Manufacturer: Metron Instrument Co., 432 Lincoln St., Denver 9.

2
4
6
8
RPM
Metron

For additional information circle MD 40 on Page 251

Adjustable Appliance Feet

Suitable for use with appliances such as electric ranges and washing machines, Type FS adjustable feet are used to level the machine so that its top is flush with mating units. Additional feature is that feet can be used in mounting the appliance or machine in its packing crate. Feet have flanges with scalloped rims which fits conventional eight-point socket wrench; flange imbeds itself in the crate as it is driven home and will not loosen. Variety of thread sizes from 10-24 to $\frac{1}{2}$-13 are available, with thread length ranging from $\frac{5}{8}$ to $2\frac{1}{4}$ inches. Manufacturer: Ohio Nut & Bolt Co., 600 Front St., Berea, Ohio.



For additional information circle MD 41 on Page 251

Hermetically-Sealed Relays

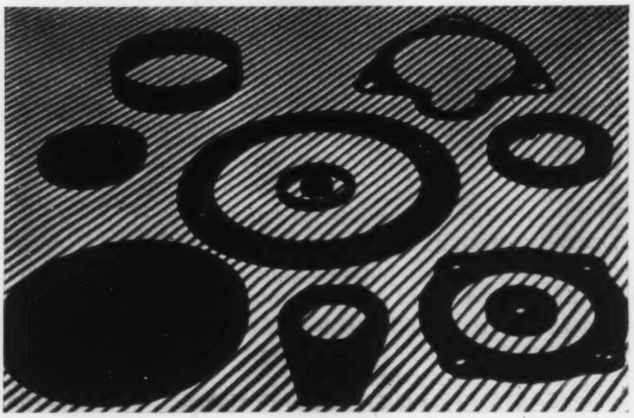
All types and sizes of Advance relays are now available in either hermetically sealed or dust-tight models. Units employ canon pressure-sealed plugs, octal plugs, solder-lugs or screw terminals. Manufacturer: Advance Electric and Relay Co., Los Angeles.

For additional information circle MD 42 on Page 251

Punched and Extruded Rubber Gaskets

Standard line of punched or extruded rubber gaskets, washers and sleeves are available in Buna S, Buna N and Thiokol as well as natural and reclaimed rubbers. These formulations provide durometer hardnesses from 30 to 100 and tensile strengths from 500 to 3500 psi with elongations from 50 to 900 per cent. Maximum size is 6 inch OD with any thickness or ID available. For special requirements, gaskets can be made of silicone rubber and built up on mandrels to 14 inches diameter. Manufacturer: The Stalwart Rubber Co., 190 Northfield Rd., Bedford, Ohio.

For additional information circle MD 43 on Page 251



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EX-CELL-O Special Machine Combines Operations to Save Handling...Save Man Hours...Save Space

This Ex-Cell-O Special Machine for turning the tapered ellipse on automotive pistons does a complicated machining job while still maintaining a high rate of production and fine finish. Ex-Cell-O used as a basis for this operation a standard Style 61 Precision Cylinder Boring Machine. Production is 180 pieces per hour net. The engineering "know-how" that makes a job like this possible is available to you through Ex-Cell-O. Write Ex-Cell-O in Detroit today! 49-8

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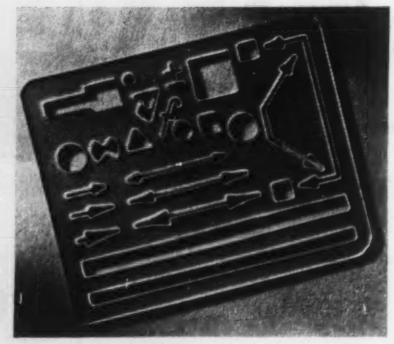
engineering dept equipment

In order to obtain additional information on this new equipment see Page 251

Drafting Template



All of the more important dimensioning symbols used in drafting are included in the No. 60 dimensioning template. Dimension lines and arrows of various lengths as well as the finish symbols and plus and minus marks conform to standard drafting room practice. The template measures 4 by 3¼ inches and is made of 0.040-inch cellulose nitrate sheet. Cutouts are milled to high accuracy. Manufacturer: Radpidesign Inc., P. O. Box 592, Glendale, Calif.

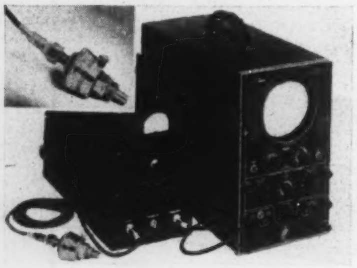
For additional information circle MD 44 on Page 251

Photocopying Paper

Contact and reflex paper for use on all types of photocopying equipment produces midnight-black lines on clear white background. The paper is of high quality stock, lying flat, and is available in any required size. Manufacturer: General Photo Products Co., 15 Summit Ave., Chatham, N. J.

For additional information circle MD 45 on Page 251

Dynamic Micrometer



Electromagnetic micrometer when used with an oscilloscope will measure movement, radial displacement or vibration of a part made of ferrous material. This Dynamic micrometer does not touch the moving part and does not interfere with its movement, yet readings can be made in tenths of a thousandth of an inch with an accuracy comparable to that of a standard micrometer. The instrument functions by means of a coil which radiates electromagnetic waves. Magnetic material coming into the field of these radiations causes a change in the reactance of the radiating coil; these changes are converted into electric voltages of varying magnitude and are used to produce a varying pattern on the oscilloscope screen. Instrument measures 12⅛ by 7 1/16 by 18½ inches and weighs 27 pounds. Manufacturer: Electro Products Laboratory Inc., 549 Randolph St., Chicago 6.

For additional information circle MD 46 on Page 251

Metal Drawing File

Fire-proof file for drawings or prints holds up to 1000 sheets, and allows any one to be removed without disturbing the others. Drawings hang vertically on suspension rods; opening of the cabinet separates rods in such a manner that sheets can be removed or inserted in their correct positions. Cabinet, tradenamed Draw-In-Dex, is constructed of fire-resistant steel, measures 20 by 30 inches by 4-feet in height, and has built-in index system and lock. Colors available include gray, green and brown. Manufacturer: Empire Development Corp., 209 Union Trust Bldg., Washington, D. C.

For additional information circle MD 47 on Page 251

Oscilloscope Camera

Using 35 mm movie film, new oscilloscope camera can be used with tubes having short-persistence screens. Either horizontal or vertical sweep can be photographed depending upon the position of the camera. Speed range is 25 to 850 inches per second on either ac or dc voltages. Proper focus is achieved by viewing the image on the film itself. Film marker functions at line frequency

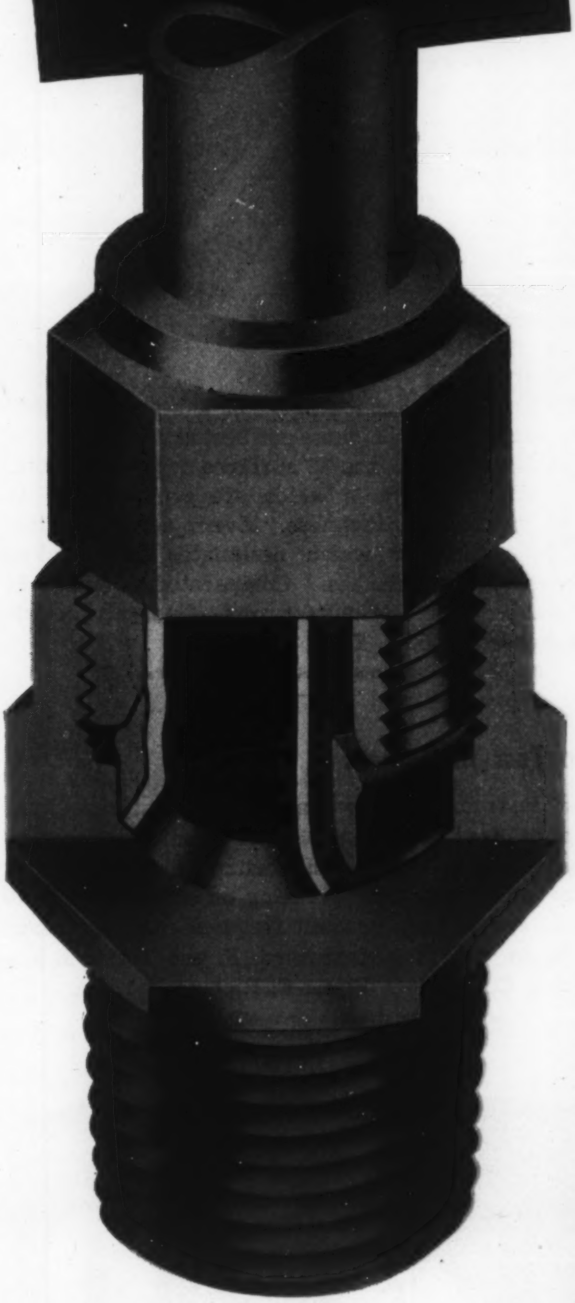
Here's a tube fitting you can't shake off— Save time, labor, and material with

Uniflare

TUBE FITTINGS

You, too, will agree with leading design engineers that Scovill's UNIFLARE tube fitting has too many advantages to be ignored.

It's a two-piece fitting that makes a perfect flared seal practically by itself . . . is so tight that the tube will burst (but not at the joint) before the fitting leaks . . . and takes repeated disassembly and reassembly in its stride.



SELF-FLARING

UNIFLARE RESISTS VIBRATION

UNIFLARE is self-flaring. No flaring tools are needed . . . no separate flaring operation . . . no cracked tubing to worry about. A novice can make a perfect joint the first time.

UNIFLARE resists vibration . . . won't shake off. Pull tests show that a UNIFLARE fitting has 3 times the strength of a compression fitting, and its special brass composition is 50% stronger in tensile and hardness than other brass fittings.

STILL ANOTHER ADVANTAGE

Because of UNIFLARE's unique design, you can use standard wall tubing rather than the much heavier tubing often required to provide the extra strength.

UNIFLARE is available in a complete range of sizes from 1/8 in. through 1 in. and in all the standard shapes. Fully tested and approved by the Underwriters' Laboratories, Inc.

SEND FOR FREE SAMPLE FITTING

If you are concerned with the specification or purchase of fittings for gas, oil, air, water or hydraulic lines, take advantage of this opportunity to see for yourself how Scovill's UNIFLARE Fitting can save you time and money. Write on company letterhead for a working sample of Scovill's UNIFLARE Fitting. Address Screw Machine Products Division, 50 Mill Street, SCOVILL MANUFACTURING COMPANY, Waterbury 91, Conn.

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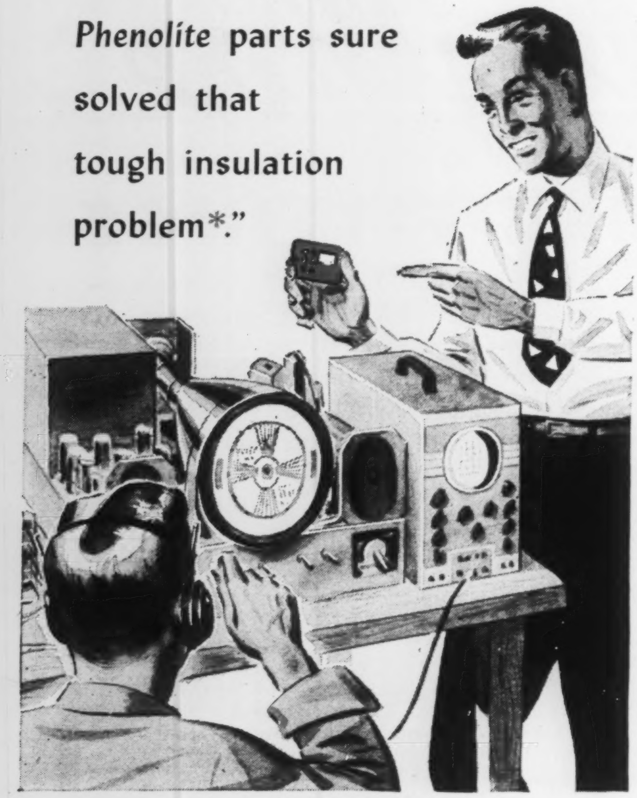
Uniflare The Complete, Self-flaring Tube Fitting



"Tiny—but these *Phenolite* parts sure solved that tough insulation problem*."

* Required:
A material with very high insulation resistance under all atmospheric conditions—with good mechanical strength and ready machinability. Phenolite, laminated plastic, with all these qualities, plus—*was the perfect answer.*

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PHENOLITE Laminated PLASTIC

About one-half the weight of aluminum, possesses an unusual combination of properties—a good electrical insulator, great mechanical strength, high resistance to moisture; ready machinability. Sheets, Rods, Tubes, Special Shapes.

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A tough, horn-like material with high dielectric and mechanical strength. Excellent machinability and forming qualities, great resistance to wear and abrasion, long life, light weight. Sheets, Rods, Tubes, Special Shapes.

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The *first* fish paper developed for electrical insulation. Strong, smooth, flexible, with excellent forming qualities. High dielectric strength. Sheets, Rolls, Coils.

To help you solve your specific development problem—available without obligation—National Research and Engineering Service.

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WILMINGTON DELAWARE
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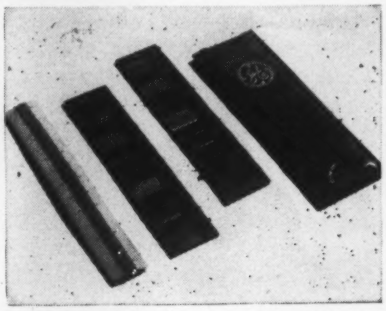
or may be connected to an external signal voltage. Starting or stopping of the camera is effected by means of a pushbutton on an 8-foot cord. A plug is provided for actuation by control apparatus. Dimensions are 5¾ by 6¼ by 11 inches; weight is 15 pounds. Manufacturer: Frederick P. Warrick, 8666 Grandville, Detroit 10.

For additional information circle MD 48 on Page 251

Pocket Surface Roughness Scales



Pocket size roughness comparator known as the "surface roughness scale" is composed of two metal plates 6 inches long and 1¼ inches wide. These bear sections illustrating degrees of roughness from the smoothness of a bearing surface to the roughness of a flame-cut section. One side of each scale is divided into 12 surfaces depicting a total of 24 different surfaces which are grouped into 10 degrees of surface roughness. Every degree is identified by a number which designates the nominal roughness in microinches. Comparator is complete with leather case. Manufacturer: General Electric Co., Schenectady 5, N. Y.

For additional information circle MD 49 on Page 251

Servo Test Instrument

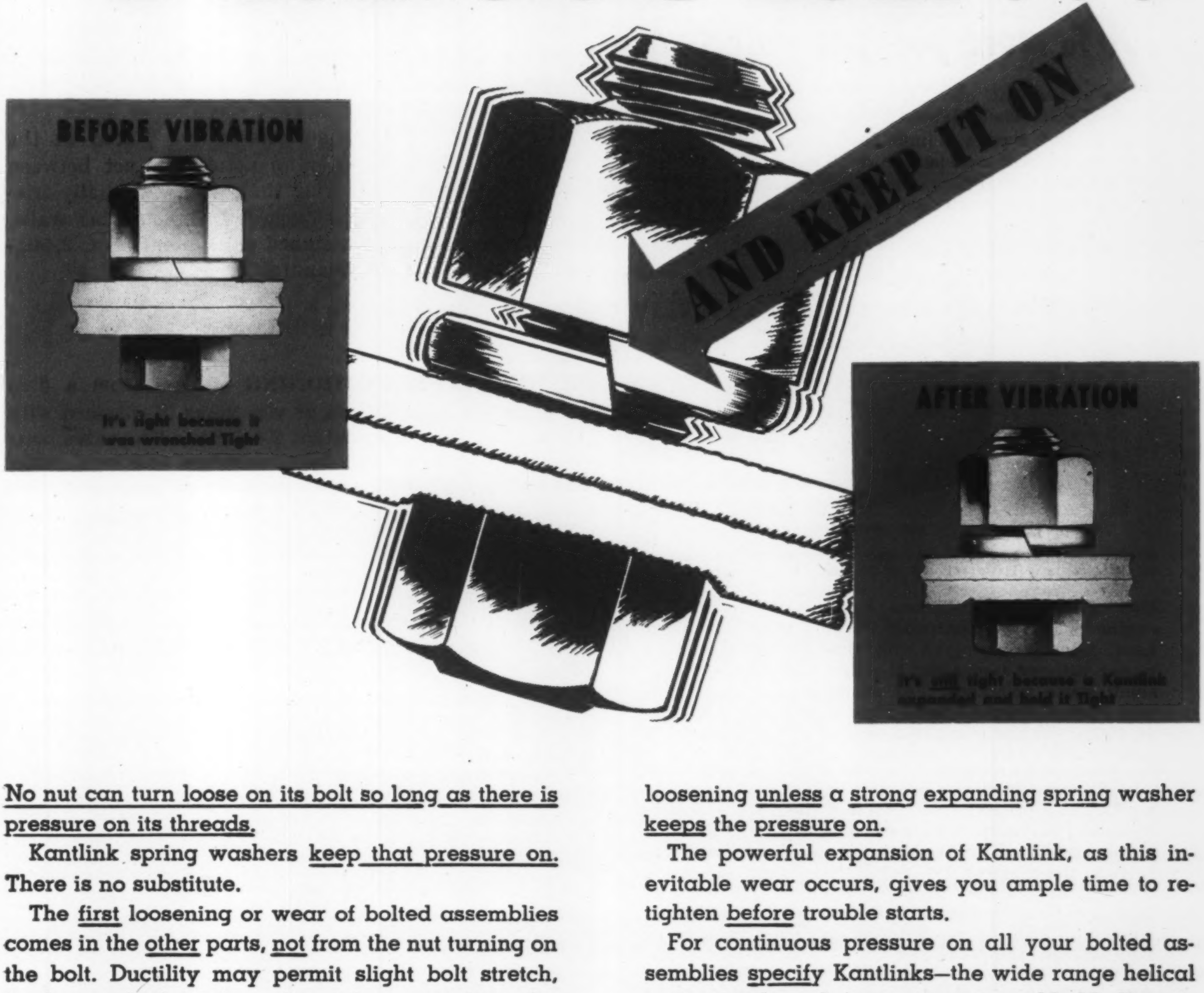
Test instrument known as Servo Analyzer—Type 5, can be used to measure the dynamic response of servos and amplifiers. The instrument is designed for use with apparatus operating on either dc or 400-cycle ac and having resonant frequencies in the range 1/10 to 60 cps. Manufacturer: Flight Research Engineering Corp., P. O. Box 1-F, Richmond 1, Va.

For additional information circle MD 50 on Page 251

SERVO-ANALYZER

Put on the

PRESSURE...


AND KEEP IT ON
BEFORE VIBRATION
It's tight because it was wrenched Tight
AFTER VIBRATION
It's still tight because a Kantlink expanded and held it Tight

No nut can turn loose on its bolt so long as there is pressure on its threads.

Kantlink spring washers keep that pressure on. There is no substitute.

The first loosening or wear of bolted assemblies comes in the other parts, not from the nut turning on the bolt. Ductility may permit slight bolt stretch, or the gradual friction of metal on metal, or the grinding down of burrs, flares, or the pulverizing of scale, rust or paint—these things cause inevitable loosening unless a strong expanding spring washer keeps the pressure on.

The powerful expansion of Kantlink, as this inevitable wear occurs, gives you ample time to retighten before trouble starts.

For continuous pressure on all your bolted assemblies specify Kantlinks—the wide range helical spring washers that are stronger, and hold all parts tight longer.

Write today for descriptive folder.

Originators of KANTLINK the long-range spring washer

TRADE MARK

THE NATIONAL LOCK WASHER COMPANY

Newark 5, New Jersey
Milwaukee 2, Wisconsin

Silicone News

DC SILICONES

100% more pull per unit size

We're dependent upon mechanical muscles in the form of solenoids activated by automatic or fingertip control. But there's a limit to the amount of work even mechanical muscles can do. That limit is set by restrictions on size or weight and by the heat stability of the insulating materials used in winding the coil.

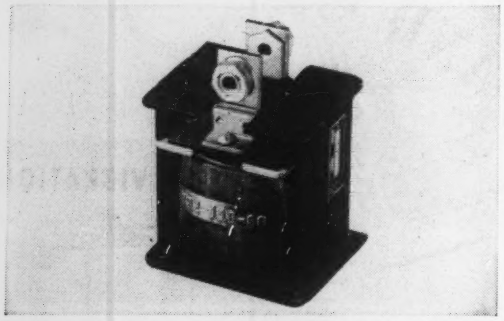


PHOTO COURTESY B/W CONTROLLER CORPORATION

Silicone insulated "Hi-Power" small space solenoids operate continuously in either 25 cycle 110 to 220 volt or 60 cycle 110 to 550 volt service.

Use of heat-stable Silicone Insulation has enabled engineers at B/W Controller Corporation of Birmingham, Michigan, to give you almost twice as much power without increasing the size or weight of their small space solenoids. For example, the new B/W "Hi-Power" solenoid has a push or pull of 32 pounds at 100% voltage compared with 17-18 pounds for a comparable Class "A" solenoid.

This increase in power per unit size is made possible by the exceptional heat stability of Dow Corning Silicone Insulation. This new class of electrical insulation gives long and continuous service at temperatures in the range of 200-260°C. "Hi-Power" solenoids operate continuously in 25 cycle 110 or 220 volts as well as in 60 cycle service up to 550 volts. DC Silicone Insulation also assures efficient operation in spite of high ambient temperatures.

And Dow Corning Silicone electrical insulation gives you more power per pound in other kinds of electrical equipment including motors, transformers, and generators. For more information, call our nearest branch office or write for our new collection of case histories on Silicone Insulation, pamphlet No. G7-B-2.

DOW CORNING CORPORATION, MIDLAND, MICHIGAN

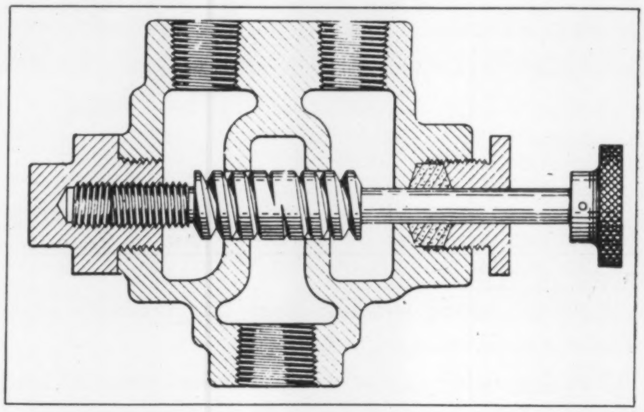
Atlanta • Chicago • Cleveland • Dallas • New York • Los Angeles
In Canada: Fiberglas Canada, Ltd., Toronto
In England: Albright and Wilson, Ltd., London

Dow Corning
FIRST IN SILICONES

Noteworthy Patents

MAGNETIC SUSPENSION of the piston in an oscillating piston displacement type fluid meter is used to substantially eliminate frictional resistance of the moving parts and thereby increase the accuracy of the meter, especially at the low fluid pressures. A support magnet fastened to the piston is attracted to an adjustable circular magnet ring on the upper part of the meter casing, supporting the piston in the fluid and, since there is no actual contact between piston and casing, allowing the piston essentially frictionless movement with respect to the chamber walls. C. P. Bergman has assigned the patent, No. 2,449,973, to the Rockwell Manufacturing Co.

PRECISE PROPORTIONING of flow from a fluid line to two branch lines or vice versa is obtained with the valve covered in patent 2,447,920. The valve body consists of a central inlet chamber and two outlet chambers. A cylindrical valve stem connecting the chambers is provided with helical grooves of vee-shaped cross section starting at the center of the valve and increasing in cross section in the direction of flow. Fluid passes from the inlet chamber to the outlet chambers through the helical grooves. Moving the valve stem axially causes a larger groove area to pass more fluid to one outlet while decreasing the flow to the other outlet. Assigned to A. W. Cash Co. by Charles M. Terry, the valve is capable of fine adjustment since a complete turn of the valve handle advances the stem axially only by a distance equal to the lead of the threaded section on the end of the valve stem.



RELATIVE ROTARY OR RECTILINEAR sliding movement between a shaft and a bearing mounted in a housing is permitted with the bearing covered in

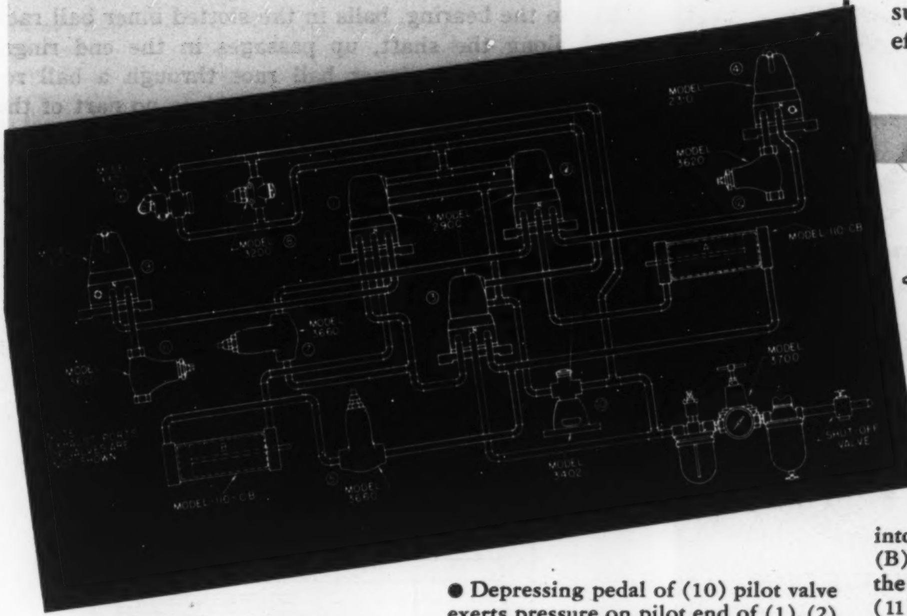
WHAT MAKES UP A *Good* Air Circuit?

1
VALVES, CYLINDERS OF SUPERIOR DESIGN

Gerotor meets this requirement with equipment designed by foremost engineers in the air field. Compactness of 4-way valves prevents fouling or leaking; large, convenient pipe connections allow unrestricted air flow. Cylinders, notable for absence of tie rods, have Keeper ring design, permitting compact installation.

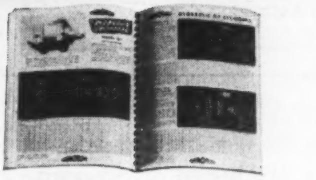
2
KNOWLEDGE OF APPLICATION

Equally important is the know-how as demonstrated by Gerotor Factory and Distributor Representatives. These men possess the knowledge and experience to help you draw up the most suitable circuit to furnish efficient and lasting service.



AIR EQUIPMENT ON AN AUTOMATIC LATHE FOR CLAMP, TURNING AND CUT-OFF

● Depressing pedal of (10) pilot valve exerts pressure on pilot end of (1), (2) and (3) pilot operated 4-way valves. Air flows from valve (3) to blind end of clamp cylinder (A). Piston moves out rapidly, the air from rod end being exhausted thru (4) cam operated 4-way valve. When clamp cylinder rod (A) depresses cam of valve (4), exhaust air from cylinder is restricted (12), providing for a slow approach. When clamp cylinder engages work, pressure in supply line increases, causing sequence valve (5) to open. Air flows into blind end of cut-off tool cylinder (B) and a similar action takes place thru the out-stroke, by means of (9) and (11). After the cut-off, cylinder rod depresses cam of (6) pilot valve which, by pilot pressure, reverses valves (1), (2), and (3). Air line is then connected to the rod end of cylinder (B) and retracts cut-off tool. After cylinder completes return stroke, pressure builds up in supply line connected to sequence valve (7). Pressure opens valve (7) and allows air to rod end of clamp cylinder. After it retracts, cycle is completed. Pilot valve (8) permits interruption of cycle to retract cylinders.



Get Gerotor Catalog Sections No. 53 and No. 301
describing air valves and cylinders
Write to
GEROTOR MAY CORPORATION
Dept. MD-3, Baltimore 3, Maryland

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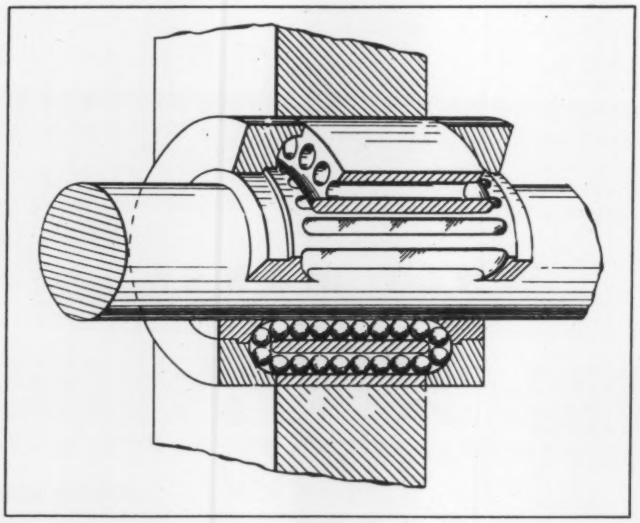
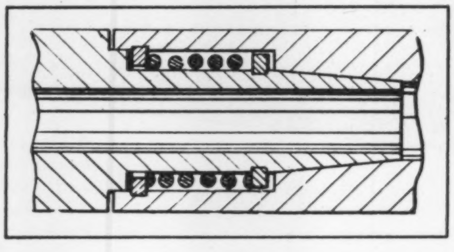


patent 2,451,359. When the shaft is rotating, balls in a slotted inner ball race sleeve transfer the radial load through an outer sleeve which is pressed into the bearing housing. All of the antifriction balls with the exception of those in the inner ball race are idle during pure rotation. When the shaft slides relative to the bearing, balls in the slotted inner ball race roll along the shaft, up passages in the end rings, and back to the inner ball race through a ball return groove in the outer sleeve. Since no part of the bearing is fastened to the shaft, any longitudinal movement of the shaft is permissible. The patent has been granted to T. F. Schlicksupp.

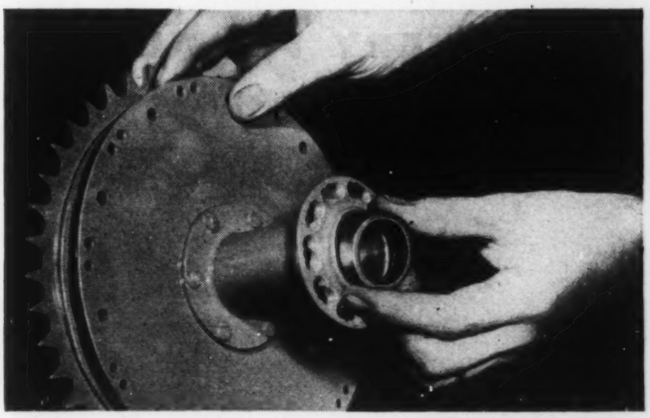
EFFECTIVE SEALING of swivel joints for pipes is achieved with the device covered in patent 2,446,327 granted to August H. Heinrich and assigned to Auto Diesel Piston Ring Co. Mating tapers on the male and female sections are honed or otherwise machined to the desired fit. A coil spring compressed between snap rings on the male and female members is used to maintain the seal between the tapered sections.



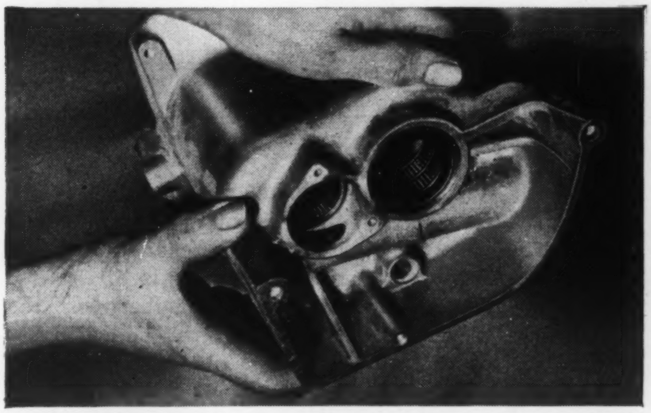
STABILIZED OPERATING TEMPERATURES for bearings subjected to wide temperature variations are possible with the heating coil described in patent 2,451,124 and assigned to the Singer Manufacturing Co. by Floyd T. Smith. The coil is fitted in a slot around the bearing hub, heat loss to other parts of

Torrington Needle Bearings Specified For Lighter Design and Longer Life In Indian Motorcycles

The new Arrow and Scout Motorcycles are designed throughout for lightness, power, safety and economy by Indian Motocycle Company. To withstand severe shock loads, reduce friction and secure compact design, Indian specifies Torrington Needle Bearings—22 in the Arrow and 24 in the Scout.



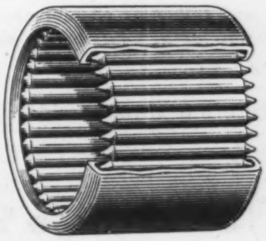
Needle Bearings take the jar of rough riding at high rotating speeds in the rear wheel hub (above) and the front wheel hub. With their full complement of small diameter rollers, Needle Bearings take less space and provide higher radial capacity than any other comparable anti-friction bearing.



More horsepower per pound is delivered by the new Indians. Power loss is reduced with 8 Needle Bearings in the transmission. Two Needle Bearings on the main shaft give unusual stability, assuring efficient sealing with the standard oil closures pressed in behind them.

Manufacturing economy is assured by the easy installation of Needle Bearings in simple, easily-fabricated housings. Needle Bearings mean operating economies, too—minimum attention for maintenance and lubrication. Past experience indicates these efficient bearings will serve the life of the motorcycles.

Lightweight design, high capacity, long service life and economical production can be yours with Torrington Needle Bearings. Our engineers will be glad to help you adapt these compact anti-friction units to the requirements of your equipment. Write us today. THE TORRINGTON COMPANY, Torrington, Conn., or South Bend 21, Ind. District offices and Distributors in principal cities.



TORRINGTON *NEEDLE* BEARINGS

Needle • **Spherical Roller** • **Tapered Roller** **Straight Roller** • **Ball** • **Needle Rollers**

There's a Cambridge

WIRE BELT

to combine movement with processing

for EVERY PRODUCT

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A Cambridge Balanced Belt safely and speedily carries clock faces through the decorating lehr. In a modern ceramics plant, Cambridge belts can also be used for annealing and glazing. Open mesh permits free heat circulation around the ware. Moving belt eliminates use of cars or saggers.

Whether your product is big and bulky or small and fragile, if it must move during processing or production, a Cambridge Woven Wire Conveyor Belt can do the job economically and safely.

Woven from any metal or alloy to any mesh or weave, Cambridge belts offer dependability, long life, freedom from time-wasting shutdowns for repairs. Among the specially designed Cambridge belts in service today are continuous conveyorized installations for baking, quenching, tempering, washing, drying, cooling and packaging.

Whenever you have a problem concerning movement during processing, call in a Cambridge Field Engineer.

Or, for complete information on the entire Cambridge line, write today for your FREE copy of this 130 page illustrated book. Gives belt and conveyor design, applications, installation data, construction details. Write today . . .

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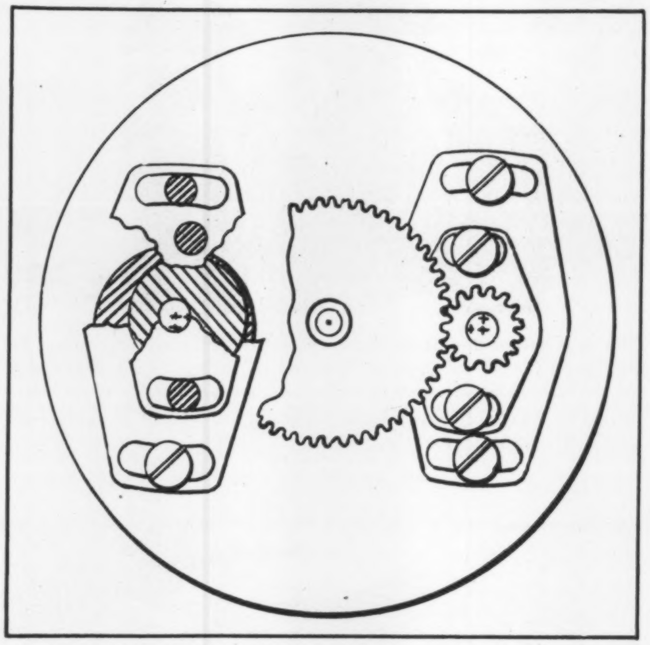
the equipment being retarded by a heat insulating cap over the bearing and coil. Current to the coil may be either hand or automatically regulated to hold a preset temperature.

BACKLASH ELIMINATOR for planetary gear trains incorporates two eccentric bushings on each of two sets of planetary gears. Both planetary gears in one set are on a common shaft. Proper positioning of one of the eccentric bushings equalizes the root clearance between the planetary gears and the sun and ring gears by moving the axis of the planetary gears radially with respect to the axis of the sun and ring gears. The other bushing rotates the planetary gears circumferentially with respect to the axis of the sun and ring gears, eliminating backlash between the upper planetary gear and the sun gear and also between the lower planetary gear and the ring gear. Two sets of planetary gears provide for zero backlash in either rotation. The device had been assigned to the Secretary of the Navy by Glenn D. Gillett in patent 2,444,734.



CONSTANT FLOW of fluid through a line is maintained with the regulating valve covered in patent 2,445,544 assigned to Bendix Aviation Corp. by Walter C. Trautman. Pressure at a venturi throat section in the outlet line is delivered to the top of a spring-loaded piston. Any variation in flow through the venturi changes the pressure at the venturi throat, causing the piston to actuate a sliding valve. This valve, through proper porting, continuously adjusts the flow of fluid to the venturi to maintain the preset flow rate from the valve. Excess fluid entering the valve is directed back to the reservoir, as when there is no flow in the discharge line.

GRAMIX SELF-ALIGNING OIL-LESS BEARINGS

Provide $2\frac{1}{2}''$ Bearing Surface on New SpeedWay Grinder

The two Gramix main bearings, with over $2\frac{1}{2}''$ bearing surface supporting the drive shaft, are helping to make the ultra-new SpeedWay Bench Grinder a preferred tool in hundreds of industries because of its ability to give dependable, trouble-free service under all kinds of shop conditions. Gramix bearings were specified because they are *self aligning, need no lubrication, and cost only a fraction of similar machined parts* made of conventional materials. Gramix parts are die-pressed powdered metals, finishing to size without machining. They are porous, retaining lubricant and releasing it as required. For these reasons, and because they cost less than conventional machined parts, they are going into scores of new uses where economy and rugged precision performance are requisites.

SpeedWay
TYPE
128

Our engineers may be able to show you how Gramix parts can improve the performance of your product and save you money. Write for your copy of the Gramix parts catalog.

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The practical answer to longer appliance utility & safety...

HEYCO

STRAIN RELIEF BUSHING
Molded of NYLON

WILL ANCHOR THE CORD SET TO YOUR ELECTRICALLY OPERATED MACHINES, EQUIPMENT & APPLIANCES

In Canada Approved by Canadian Standards Association #8919

IT'S EASY TO APPLY THE HEYCO
1. Slip Heyco on wire
2. Snap Heyco into chassis hole

Look what HEYCO does!
1. ABSORBS CORD PULL, PUSH AND TORQUE
2. INSULATES WIRE FROM CHASSIS
3. PREVENTS WIRE FROM FRAYING
4. ELIMINATES TYING WIRE KNOTS

● The Heyco is a Nylon insulating grommet that grips the wire in a vise-like grip in addition to insulating the wire from the chassis. It does not injure the wire yet it anchors it firmly to the product, thus preventing strain on terminals. Heyco eliminates cord wear at chassis entrance and is available with spring extension for applications requiring wire movement. Illustrated Bulletin on request.

HEYMAN MANUFACTURING COMPANY
KENILWORTH 2, N. J.

And it improves Product Appearance at low cost!

TEST SAMPLES SENT ON RECEIPT OF WIRE SPECIFICATIONS

CHASSIS
HEYCO

HEYCO ELIMINATES STRAIN ON TERMINALS

Assets to a Bookcase

Elementary Mechanical Vibrations

By Austin H. Church, professor of mechanical engineering, New York University; published by Pitman Publishing Corp., New York; 200 pages, 6 by 9¼ inches, clothbound; available through MACHINE DESIGN, $3.25 *postpaid.*

Based on courses given at New York University, this text presents the basic material required for the solution of vibration problems. A physical explanation of vibration phenomena has been relied on rather than a complicated mathematical analysis. Subjects treated include undamped forced and undamped free vibrations, damped forced and damped free vibrations, undamped vibrations with two degrees of freedom, equivalent torsional systems, multimass torsional systems using the Holzer method, multimass lateral systems, and balancing. The book is written for those having an understanding of the usual engineering courses in mechanics and calculus.

* * *

Introduction To Gas-Turbine and Jet-Propulsion Design

By Carl A. Norman, professor of machine design and gas turbine work, and Richard H. Zimmerman, assistant professor of mechanical engineering, Ohio State University; published by Harper & Brothers, New York; 286 pages, 6 by 9½ inches, clothbound; available through MACHINE DESIGN, $5.00 *postpaid.*

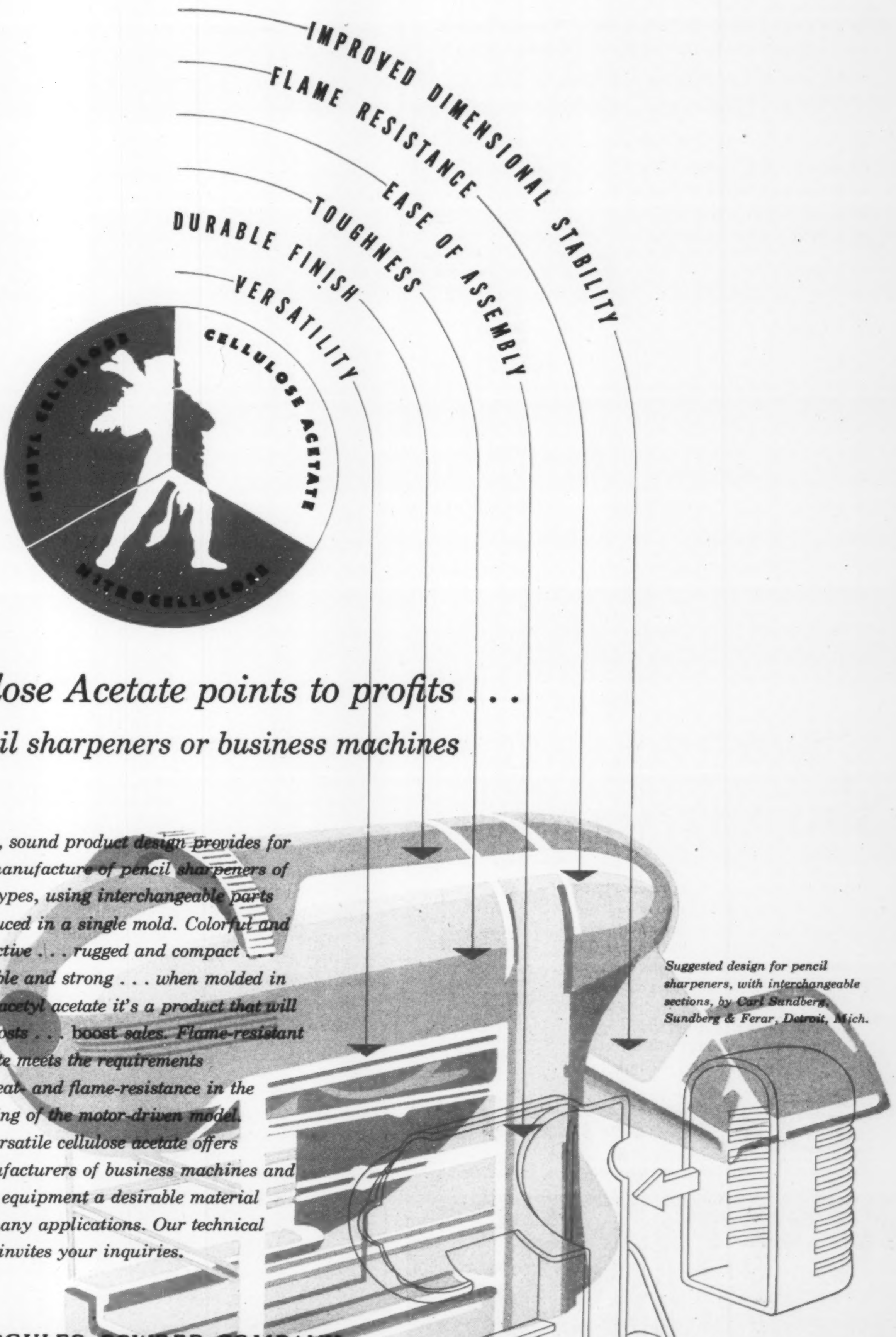
This book deals with the design and performance of gas turbines and jet propulsion apparatus for stationary, aircraft, marine, and locomotive plants. Written primarily as a basic text, all theoretical complexities that do not lend themselves to fundamental understanding and ready use in design have been avoided. One chapter is devoted to a discussion of rockets; combustion chambers, compressors, materials, and general design considerations are covered elsewhere.

* * *

Mathematics At Work

By Holbrook L. Horton; published by the Industrial Press, New York; 728 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, $6.00 *postpaid.*

Written as a working manual intended for machine designers, tool engineers and mechanical draftsmen, this book illustrates the practical application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Cellulose Acetate points to profits . . .

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Here, sound product design provides for the manufacture of pencil sharpeners of two types, using interchangeable parts produced in a single mold. Colorful and attractive . . . rugged and compact . . . durable and strong . . . when molded in high-acetyl acetate it's a product that will cut costs . . . boost sales. Flame-resistant acetate meets the requirements for heat- and flame-resistance in the housing of the motor-driven model.

Versatile cellulose acetate offers manufacturers of business machines and office equipment a desirable material for many applications. Our technical staff invites your inquiries.

Suggested design for pencil sharpeners, with interchangeable sections, by Carl Sundberg, Sundberg & Ferar, Detroit, Mich.

HERCULES POWDER COMPANY
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996 Market Street, Wilmington 99, Del.

CPS-2

Two Chambers Each Containing One Packing Ring
Two Chambers Each Containing Two Packing Rings

PROBLEM: Provide a seal for turbines that will hold high pressure live steam...resist corrosive forces...function without conventional lubrication.

SOLUTION: Morganite Carbon Seals — self-lubricating qualities resist temperature extremes . . . nullify the factor of inaccessibility... are immune to corrosion...prevent wear.

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SELF-LUBRICATING, HIGH PRESSURE
SEALS, RINGS and WASHERS

The successful application of self-lubricating seals in high pressure lines is another example of the basic advantage of Morganite Dry Lubrication — an inherent lubrication that equals the life of the seal without renewal. Full retention of steam, from cold start to full-load high temperatures, is assured. Surface scoring, which opens the way for rapid surface erosion by live steam, is eliminated.

See our CATALOG in SWEET'S FILE for PRODUCT DESIGNERS

For detailed information consult the Morganite Catalog in Sweets File for Product Designers; for engineering counsel, call Morganite

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LONG ISLAND CITY 1, NEW YORK

Manufacturers of Morganite Carbon Brushes for all motor and generator applications, and Morganite Carbon Piles.

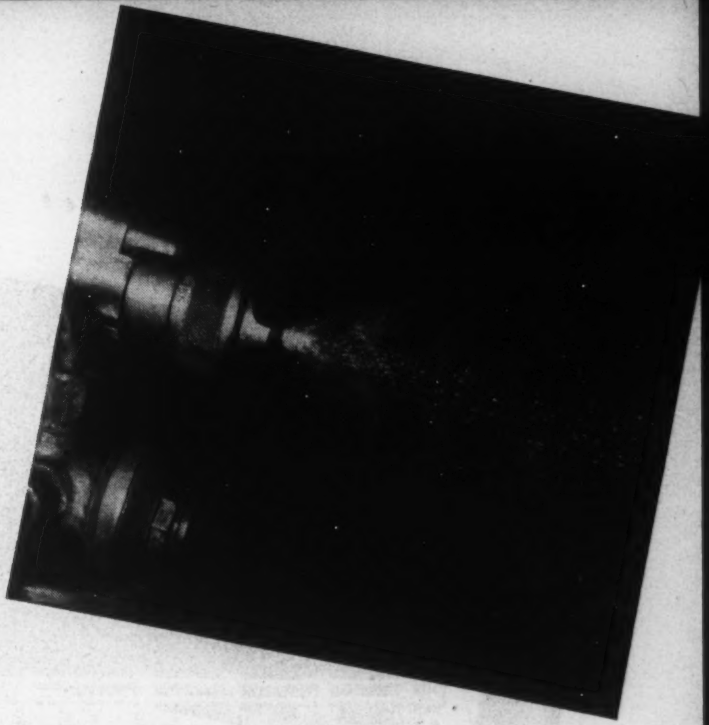
of arithmetic, algebra, geometry, trigonometry, and logarithms to a wide variety of mechanical problems taken from actual practice. In the presentation of each problem, the reader is shown how to develop a method of analysis and attack, what formula to apply, how that formula was developed, and how a typical problem is worked out using the step-by-step procedure. Examples and problems illustrating a common mathematical principle or method have been grouped together for ease in finding the general type of problem in question. Problems in the use of approximate formulas, mechanics and strength of materials, obtaining gear ratios by exact or approximate gear combinations, determining what happens in planetary gearing, trial and error solutions, and the appearance and systematic handling of errors are among the many topics discussed in the book.

A supplement to the Metal Powder Association's *Standard* 4-45, a method for the determination of apparent density of metal powders, was recently published. The supplement presents a statistical evaluation of the precision of the Hall Flowmeter as an instrument for determining apparent density and was prepared by the Association's granular powders standards committee. Copies of the supplement are available from the Association's offices at 420 Lexington Avenue, New York 17, at 25 cents per copy.

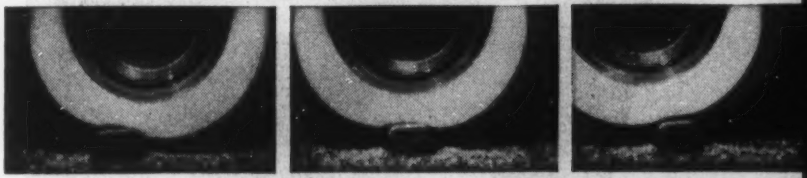
Submitted as being what is considered good engineering practice in the pump industry, the eighth edition of *Standards of Hydraulic Institute* is a collection of pertinent technical and engineering pump data. Containing six sections—general, data, centrifugal pump, rotary pump, reciprocating pump, and a new section covering tentative standards on pipe friction, the standards define products, materials, processes and procedures with reference to one or more of the following: Nomenclature, composition, construction, dimensions, tolerances, safety, operating characteristics, performance, quality, rating, testing, and service for which designed. Copies may be obtained from Hydraulic Institute, 90 West Street, New York 6, for $3.00.

A new 8-page folder announced by New York University College of Engineering and titled *Possibilities For Heat Pump Expansion* discusses future outlook with reference to heat pump application, heat and energy sources, types of systems, cycle, and distribution. Illustrated with charts, curves, photographs and line drawings, the booklet compares operational factors for residential, commercial and industrial installations and gives dimensional data on typical residential units having heating capacities from 34,000 to 116,000 Btu per hour and with cooling capacities from 32,000 to 126,000 Btu per hour. The folder is available from V. W. Palen, Bureau of Public Information, New York University College of Engineering, 181st Street and University Avenue, New York 53, for 10 cents.

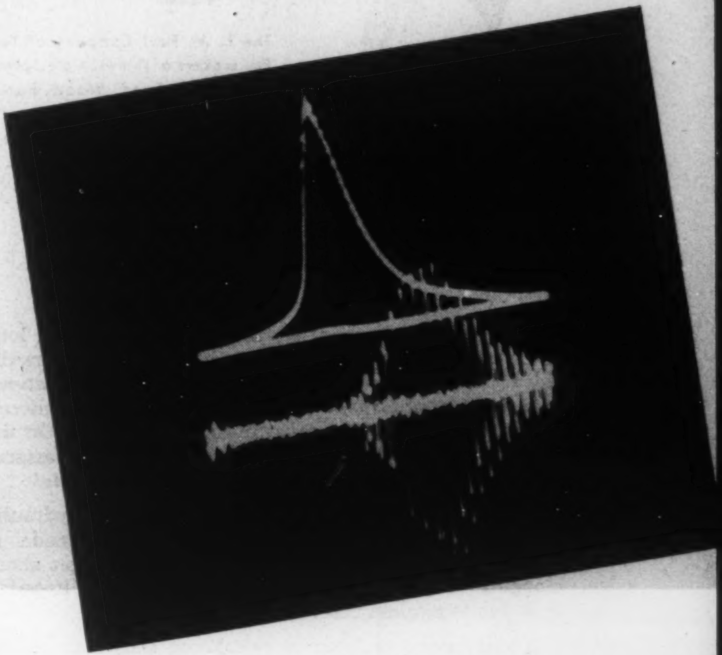
3 WAYS PHOTOGRAPHY STOPS TIME



1. HIGH SPEED STILLS—taken in as little as a millionth of a second—give you sharpest possible detail of a flash of fast action. They can be timed to catch the important instant of continuous motion. In the illustration, taken at 1/100,000 second, spray from a lacquer gun has been "stopped" to study dispersion of material.



2. HIGH SPEED MOVIES—slow down action far too fast to see otherwise—expand 1 second of operation into 4 minutes of viewing time. They allow the study of fast moving parts in operation—show why they stand up or fail. The illustration shows three frames of a high speed film made to study the action of a tire meeting an obstacle at high speed.



3. RECORDING OSCILLOGRAPH TRACES. When fast actions can be translated into electrical impulses, they can be traced on the oscillograph and photographed. In the illustration, the upper trace represents the pressure of detonation in the cylinder of a knocking gasoline engine—the vibrations in the lower trace have a period of about 1/100,000 second.

FUNCTIONAL PHOTOGRAPHY

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Design Abstracts

Why Plastics Fail

THERE are no such things as "bad" plastics. All plastics are "good" if they are properly used, and if they are properly compounded for a given use. If anyone attempted to use cellulose nitrate for a frying pan, he, not the material, would be blamed for the trouble that followed. So when a phenolic is used in a high-frequency connector where failure occurs because of arcing and tracking, why blame the material? Whoever decided on the use of phenolic is at fault; he should have specified melamine.

There is no reason for failure of plastic materials. They are the end product of a manufacturing process, and as such can be designed to provide the characteristics required for the application, within limits imposed by the possibilities of the basic materials and by the manufacturing process.

When a failure occurs under such circumstances, it is apparent that the wrong material has been used. Sometimes it is because of insufficient knowledge of the capabilities and limitations of the plastic, as is the case when women attempt to iron garments with plastic zippers, or when a molder tries to mold Saran in conventional equipment without making the necessary changes in the metal used in the hot zone portions of the injection machine. Sometimes it is because of improper design of the molded part, such as sharp edges or corners without adequate fillets. But most often it is because of insufficient knowledge of the requirements of the application.

All Factors Must Be Considered

The basic reason for failure is thus the use of improper standards of performance, whether they be in evaluation of the plastic, the molding process, or the application. The standard of performance may be insufficient for the reasons just discussed, or it may be incomplete in that it does not cover all the factors involved. Too often failures occur because only primary characteristics are considered, with no thought being given to subsidiary characteristics. In establishing the standard of performance for a material as dictated by the application, all factors, of use as well as of performance, must be considered.

Standards of performance are described in specifications for plastic materials. The specifications issued by the different standardization groups serve several purposes. First, they establish standards of performance for each type of plastic so that it is possible to determine performance and the possibility of a type performing satisfactorily in an application. Secondly, by the fact that they establish standards of performance by types rather than by materials, they make available several sources of supply for an application, since once a type is found successful, all materials conforming to that type may be used. Thirdly, they provide methods of evaluating

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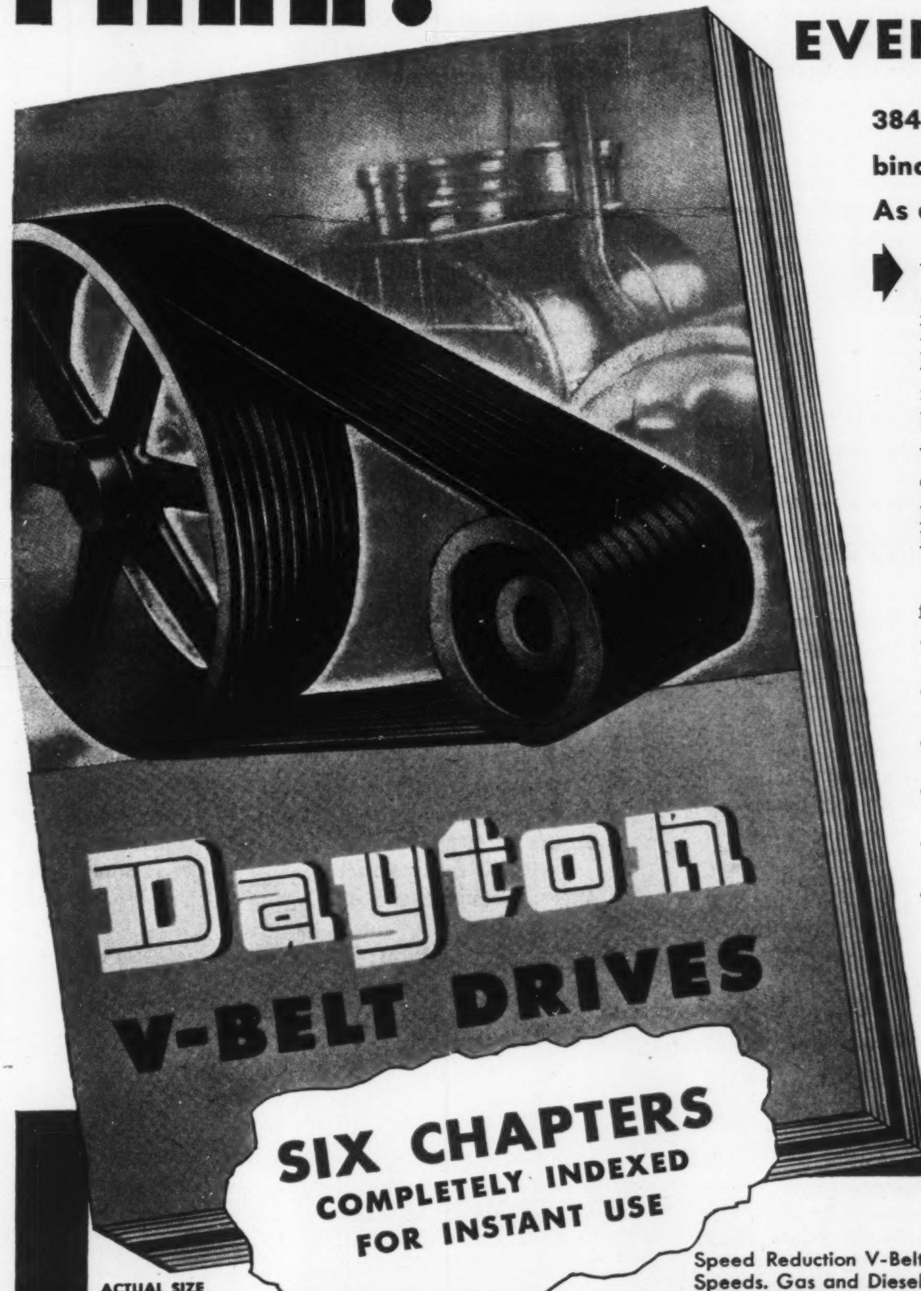

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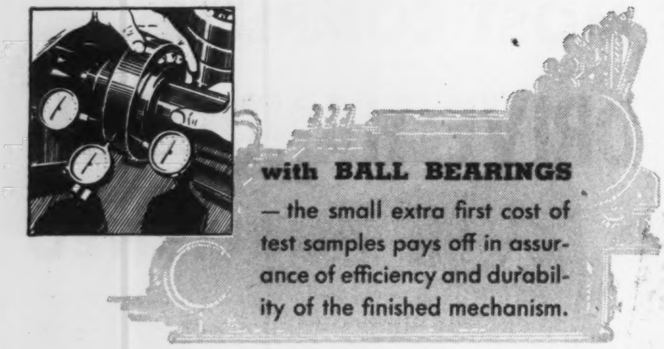

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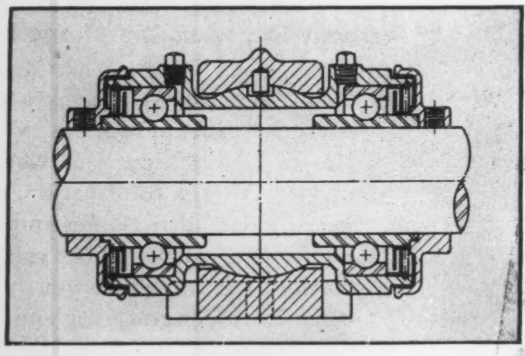

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performance of materials which do not fall into any of the standard types, but which may be used, when suitable, if some indication of their performance could be gained.

The failure of a plastic is the failure, not of the material, but of whoever used it incorrectly. There is no royal road to the choice of the proper plastic for an application. Complete evaluation of the requirements of the application and complete evaluation of the performance of the material is the only way it may be done.

Specifications and standards groups in industry and in the government are providing standards of performance against which to evaluate plastics. They work together to improve such standards and specifications, to make them more efficient, to increase their significance, and to eliminate divergence between the different groups.

The users of these standards of performance must make full use of them. They must be aware of their shortcomings and advantages, and of their significance. They must be able to interpret results correctly, and use them intelligently. They must, in effect, follow the work of the standards groups and take part in it, if the standards are to be made as efficient and as useful as needed to provide the plastics required to perform successfully in the field.—*From an address by I. L. Rosenheim presented at Remobilization Program sessions during the Third National Plastics Exposition in New York.*

The Power-Source Outlook

TAKING into account the complete facts would indicate a pessimistic minimum of some 20 to 25 years petroleum supply at present consumption, a maximum of 40 to 50, and one cannot pin it down any closer. These figures include, for the maximum, consideration of increased efficiency in use of petroleum fuel in engines.

One thing is certain; whatever this country had as original oil, it has developed its resources at a very much higher rate than the rest of the world and therefore now has much less of its original supply than any other country. We have supplied more than 60 per cent of world consumption during the last few years.

Without going into details or any discussion of the authority of estimates, our present consumable sources of power and heat stack up as follows:

Years Reserve at 1947 Total Consumption

	Maximum	Minimum
Coal	1700	170
Petroleum	16	5
Natural Gas	12	5
Oil Shale	32	8
	1760	188

This table is prepared on the basis of *each* of the fuels being used for the whole energy supply for heat and power for 1947, so the whole can be added to arrive at a total energy supply. The huge difference between the maximum and minimum estimates is due

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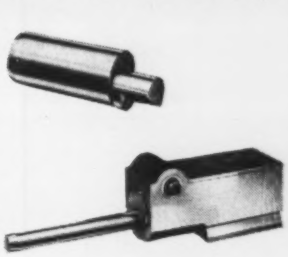

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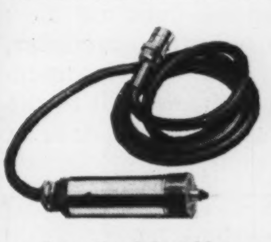
Range ½″ to 2″. Frictionless. No pivots to wear. One master only. One measuring point and measuring bar serve any plug.



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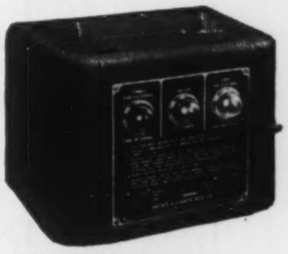

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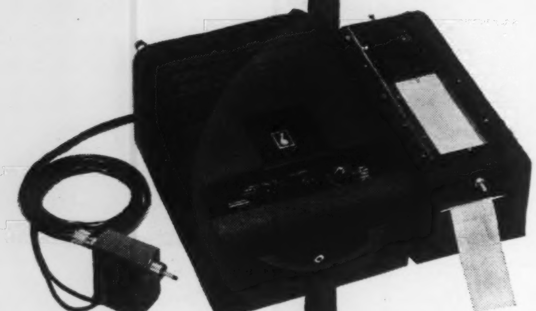

"Contour Analyzer" consisting of pickup head, BL-309 Amplifier and Brush Direct-Inking Oscillograph.

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Specifications

Displacements measurable, 10 to 10,000 microinches
Frequency Response (overall) .... Essentially uniform d-c to 100 cps
Feeler Arm Travel .... .015" approximately
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Minimum .... approximately 1½ oz.
Amplifier Dimensions .... Length, 17¼"... Width, 11"... Height, 7½"
Amplifier Power Requirements .... 100 watts

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principally to two factors: first, we have in many cases greatly reduced the estimated reserves in coal by recent surveys, not yet complete; second, the minimum estimates take into account *recovery* of these reserves, which is never 100 per cent. Coal used to be about 50 per cent, is now nearer 70 per cent and may improve; oil was 10 to 20 per cent, is now nearer 70 per cent and in some cases has reached as high as 85 per cent.

We do not know the ultimate reserves in oil, natural gas or oil shale because they have not been all discovered yet. In the case of oil shale, we do not know the efficiency of recovery. However, one thing is certain; the safest estimate of resources will be down toward the minimum, and in any case petroleum, natural gas and oil shale are relatively small in both estimates. It is therefore quite plain that if we are to get the requisite liquid fuel required for all automotive use, efforts should be directed to accomplish the following:

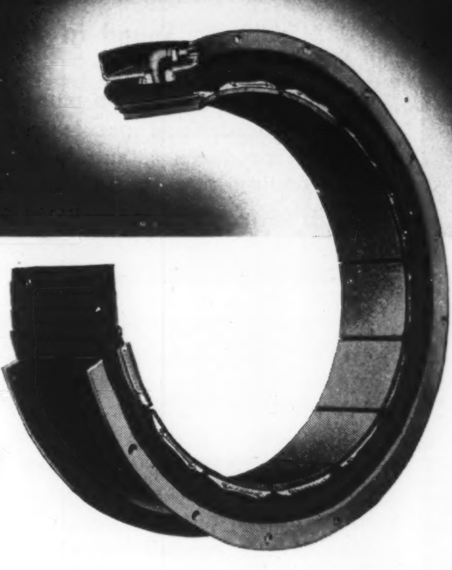
1. Designers should consider the transfer of all energy use possible from liquid to solid fuel, reserving liquid and gaseous fuels for those operations that cannot do without them
2. Raise the efficiency of all heat and power transformations; the automobile has 5 per cent overall efficiency; utilities power generation is now 20 per cent; steam locomotive, 5 per cent—pretty bad. But we know these can be raised and in many cases they are being raised now
3. Determine the best methods for supplementary supply of liquid fuels, at the nearest to reasonable economic production and permanence. Much is being done on this now.

We must supplement our petroleum production with other sources, not tomorrow, but within a moderate space of years—10 to 20 say. Synthetic production costs will undoubtedly come down and petroleum products may go up. Consequently, within a few years, schemes of synthetic production which now cost too much, may approach economic feasibility. Shale oil and synthetics from coal, since they have both been worked on for 25 years and have reached a possible production state, should receive the major development effort. This effort should be paralleled by development of synthetics from vegetable waste (lumber and other) and a reforestation program worked up to make the supply permanent. By this time, we should expect sun and wind power to be developed enough to take some of the load off coal, permitting its diversion to synthetics.

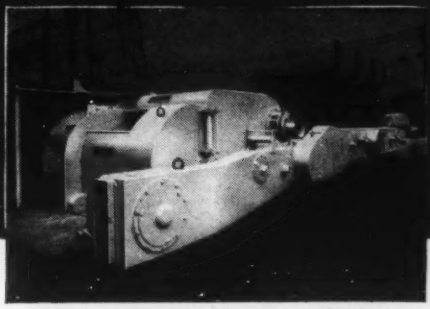
What Engine Improvements Offer

In the interest of economy, we look to increase of engine compression and expansion ratio. The important question then arises—what effect will this increase have, not only on fuel, but on lubrication? It has been shown above that the new single-stage compression engines at 12.5 compression ratio would require 100-octane fuel. We can't make present full volume that high yet, so the refining chemists tell us. At any rate we have two methods—dual fuel and

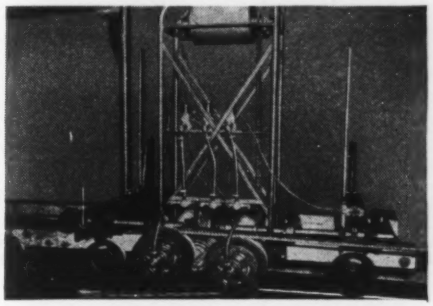
ONLY ONE MOVING PART *in this Fawick Clutch*



Fawick Airflex Clutch or Brake Type CB



7 Fawick Airflex Clutches on Unit Rig and Equipment Company Drawworks Model U-30.



5 Fawick Airflex elements on Draper Engine Works Carriage and Setworks on Portable Mill.

Fawick Airflex Clutch on drive of Swaging and Reducing Press.

The rubber-and-fabric pneumatic tube faced with friction shoe assemblies is the only moving part in this Fawick Clutch. This part naturally stays in perfect adjustment at all times—automatically compensating for wear of the friction shoes.

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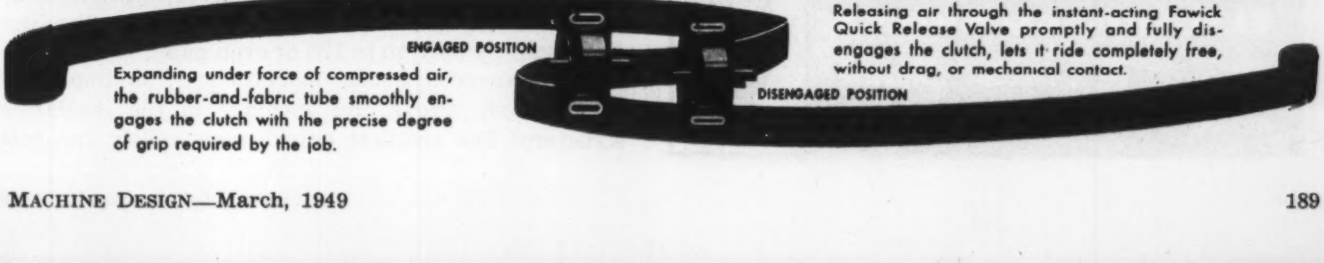

Expanding under force of compressed air, the rubber-and-fabric tube smoothly engages the clutch with the precise degree of grip required by the job.

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aftercooled supercharging—which can run this high compression on the present gasoline. So we may feel this situation is under control. In our opinion, the oils we have now will handle the higher compression engines of the future because designers no longer expect a miracle oil to correct an inadequate design. It seems to us that the war accomplished one good thing; it showed both designers and oil producers more nearly *where* the effort should be spotted to make a design and a lubricant team up well.—*From a paper by R. J. S. Pigott, chief engineer, Gulf Research and Development Co., presented at the recent SAE annual meeting in Detroit.*

Sound in Aircraft

THE roar of two or more engines and propellers in an airplane passenger's ears at the time of take-off produces a "numbing" sensation in the ears. This feeling remains in the ear for some time. The sensation of sound is produced by alternating air pressures in the sonic range. Measurement of these varying pressures is not a guide to loudness. Change of sound intensity, as the human ear feels it, is proportional to the fractional increment. Hence the perception of sound increases far less rapidly than the pressures.

Overall intensity or loudness is not a satisfactory indication of comfort or discomfort. The sensation varies with the frequency. A high-pitched noise, of the same loudness as a low-pitched noise, will produce much more annoyance. Therefore, in addition to knowing overall sound levels, it is important to measure the intensities of various frequencies in a noise containing a wide range of frequencies. Measurements taken on this basis indicate that noises may be less distressing when the higher frequencies are suppressed even if overall loudness is only slightly decreased.

Analysis Conducted in Eight Frequency Bands

In aircraft applications, a coarse analysis of the various frequencies present is sufficient. The range of audible frequencies is divided into band widths of one octave, and the range from a very low 40 cycles per second to a shrill scream of 10,000 cycles per second can be covered in eight bands. Thus, noise levels may be defined in terms of decibels in a given frequency band. The permissible levels for noise in commercial aircraft should not exceed 90 decibels in the 75 to 150 frequency range and 65 decibels in the 1200 to 2400 frequency range. Examination of typical sound values as encountered under familiar circumstances will provide a comparison of decibel levels. For example, a passenger car moving at 30 miles per hour measures 60 to 70 decibels; an air-conditioned railroad coach shows 85 decibels at 50 miles per hour; a trolley car registers 90 decibels; the New York subway may go to 120 or even more.

For successful sound insulation, it is important to avoid all cracks and openings in the insulating structure. The smallest cracks may nullify the best sound-proofing treatment. Apparently, sound entering through a narrow aperture can produce almost the same sensation of loudness as an open window. Sealed openings around hatches, doors, windows, and ventilators must be in good condition. As much of the area of the airplane structure as possible should receive acoustical treatment and the areas of untreated metal surface must be held to a minimum.

One successful sound-insulating method employs two blankets of sound absorbing material separated by an impervious septum. The thickness of the two blankets may be as low as ¾-inch, and the treatment is so effective that the minimum weight is only 0.15 pounds per square foot, excluding the weight of the trim cloth, septum, and muslin container.

The fundamental idea in acoustical insulation is, therefore, a maximum area of fiber in proportion to weight. Glass fiber is used at the present time because of this factor. Sound levels in modern aircraft have been reduced to a remarkable degree in comparison to the aircraft produced 10 years ago.

Proper sealing of doors on a maintenance basis is one of the prime factors for sound control in nonpressurized aircraft. Dampening of vibration in metals such as air outlets and galley components is also in this category.—*From a paper by John J. Harrington, Northwest Airlines, Inc., presented at the recent SAE annual meeting in Detroit.*

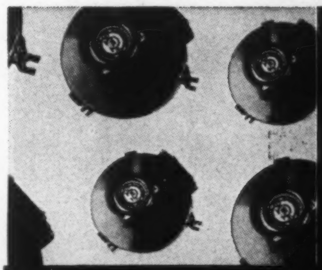
Creative Engineers

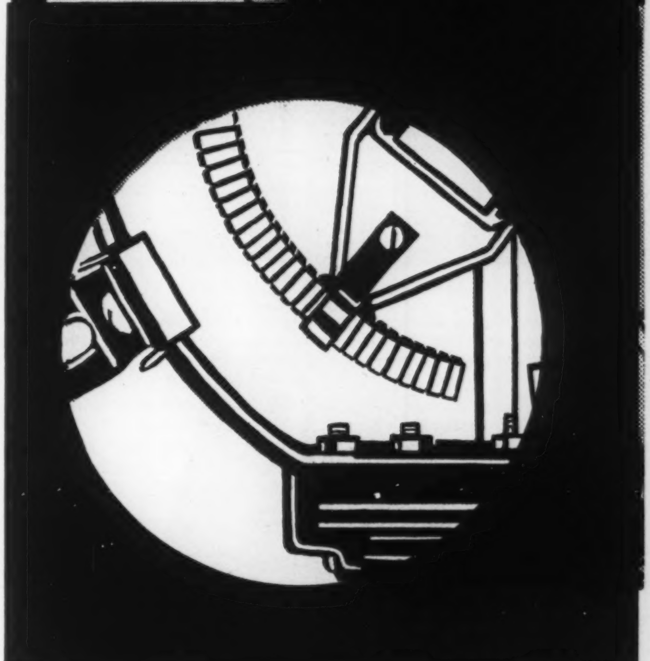
(Concluded from Page 94)

stimulation to any inventor and may result in a new product for the concern. In this manner an inventor can be free to work on some of his own ideas. The creative engineer can be most fruitful when he is not distracted by inadequate tools and poor working conditions in general.

Frequent meetings should be held to discuss new designs and developments made by associated engineering sections. These should include discussions of the problems arising in the various development programs. Outstanding contributions of an individual to a design should be recognized and presented to the whole engineering group. This gives the engineer the satisfaction of knowing that his efforts are appreciated by his associates. He receives as much, if not more, encouragement from this as he does from monetary advancement. No one likes to have his ideas unnoticed, or even worse, claimed by someone else. Suggestions should, and can, be freely exchanged within a concern as long as due credit is given.

The preceding discussions have been an attempt to show how creative ability can be discovered, developed, and employed in industry. In the General Electric Co. this is being done in the creative engineering program on a large scale for the whole company. It is also making progress in a less elaborate form in smaller units of the company. This experience shows that industry, large and small, can do much in the improvement of creative ability if it will but make the effort.





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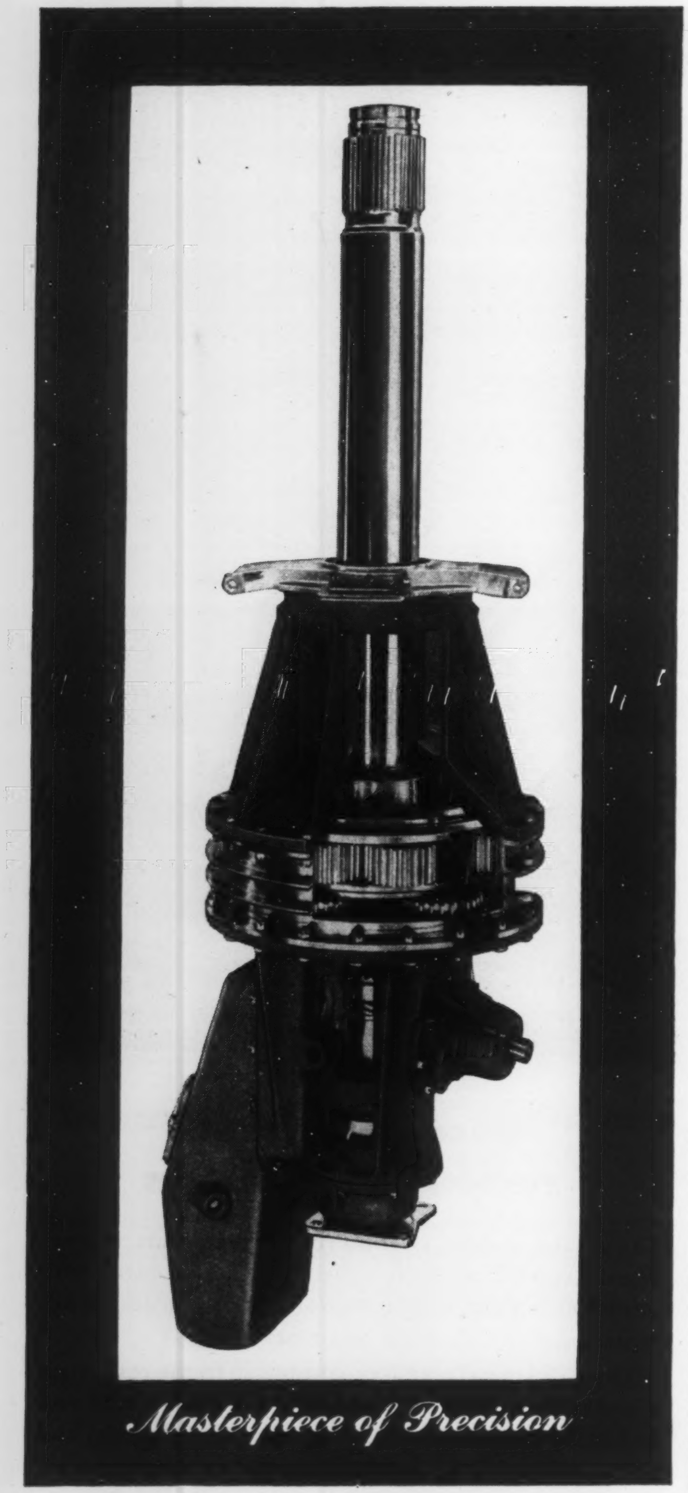

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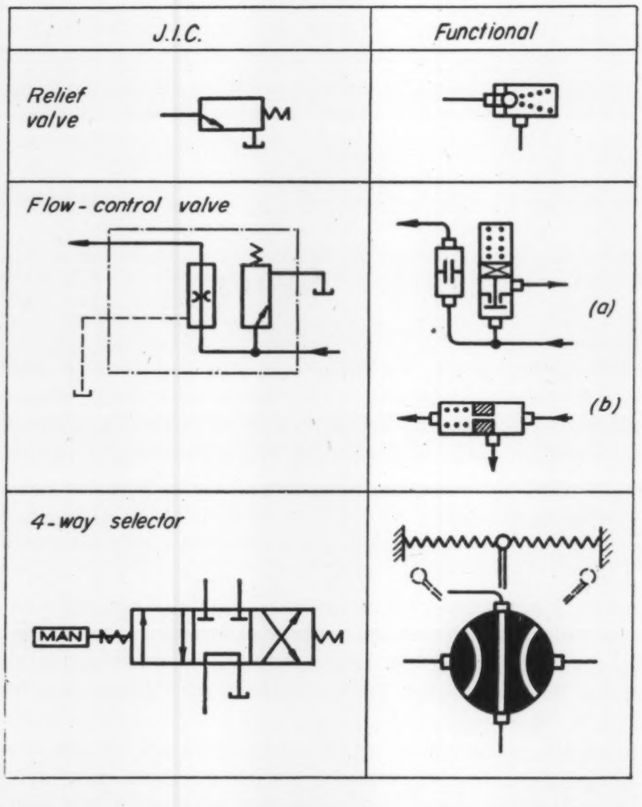
Professional Viewpoints

". . . symbols too electrical in flavor"

To the Editor:

Publication of the J.I.C. "Hydraulic Standards for Industrial Equipment" (MACHINE DESIGN, Dec., 1948) illustrates well the noteworthy efforts of the committee in particular, and American industry as a whole, to further the industrial application of hydraulics in machines. The standards should provide an excellent basis for future development.

However, comment is called for on one section, namely, standard symbols. It is submitted that the underlying principles on which these symbols have been drawn up are too electrical in flavor. Hydraulic components are mechanical devices, usually simple, and are invariably capable of diagrammatic representation on a functional basis.



To illustrate this point, the accompanying sketches have been prepared. In the left-hand column are the J.I.C. symbols for certain types of valves and in the right-hand column are functional diagrams for the same valves, based on a published British aircraft standard. The latter are no harder to draw, but it may well be asked, "Which are easier for the ordinary shop mechanic, to say nothing of the hydraulic engineer, to understand"?

—H. G. CONWAY
British Messier Ltd.
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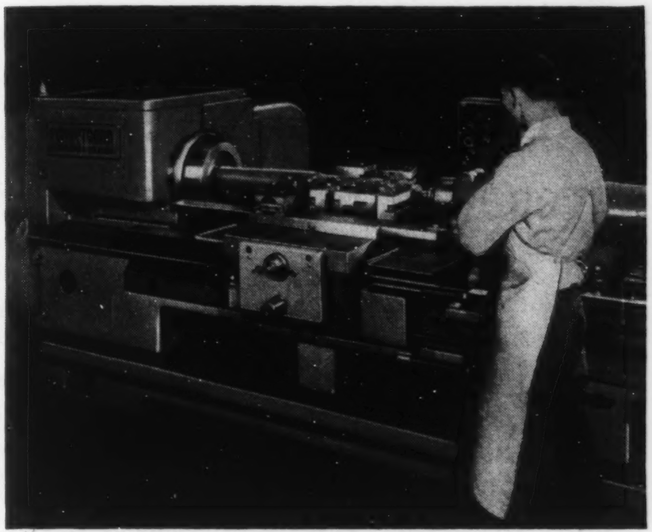
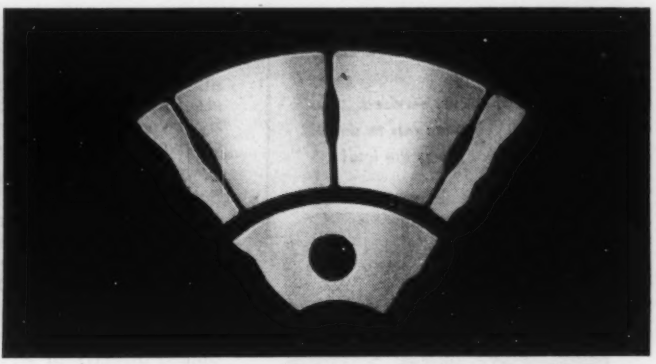
give it a Brake*!

***And the Brake to give it is a WARNER ELECTRIC INDUSTRIAL CLUTCH-BRAKE**

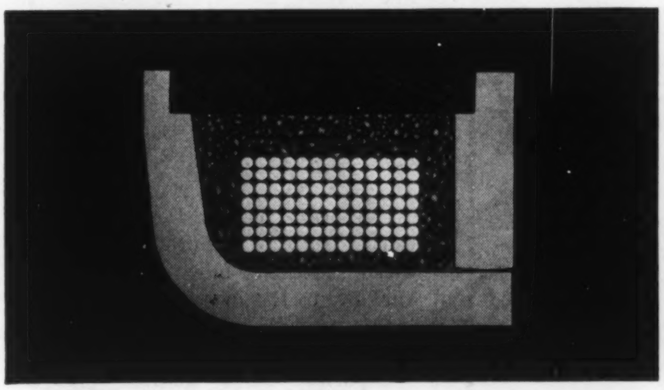


SUNDSTRAND MACHINE TOOL CO. USES 3 Warner Electric Industrial "ICB" units on their Model 16 Automatic — Two on main spindle drive and one on rapid traverse. Here's what they say about them — "Easy to Control." Main drive motor is standard 75 hp. and constantly running. Warner ICB* units give positive instant control for starting and stopping of spindle. That means short cycle time . . . no special electrical equipment . . . no sudden power surges on factory lines.

HERE'S WARNER ICB UNITS installed on drive shaft of Sundstrand Model 16 Automatic. Sundstrand says these units are "compact, easy to install" . . . and most important "need no adjustment." ICB Units are available in wide range of sizes to meet requirements. Can also be fitted to standard NEMA motor shafts.



ARMATURE SECTION: One of only two parts for either Clutch or Brake units. Consists of magnetic segments welded to steel backplate (see cut). Especially designed for high heat dissipation. Heat has no effect on unit efficiency because segment expansion is always linear . . . thus keeping full magnet contact at all times.



MAGNET SECTION: The other of the two parts for either Clutch or Brake units. Consists of electro-magnet faced with long-wearing, high friction material. Power, applied through coils imbedded below (see cut), uses both friction *plus* magnetic attraction for fast, super-powerful clutch or brake action.

- Warner ICB Units* are low-cost key to more automatic, safer operation of wide variety of motors and machinery . . . give you infinite control of degree of clutch or brake action. For details or engineering assistance write: INDUSTRIAL DIVISION, WARNER ELECTRIC BRAKE MFG. CO., Beloit, Wis.

WARNER

ICB UNITS

*ICB Unit — The trade designation for the Warner Electric INDUSTRIAL CLUTCH OR BRAKE UNIT.

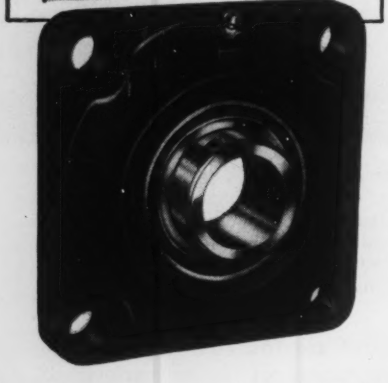
"These great **NEW** products by Boston Gear save you time and money . . . make your job easier"

Designers . . . Manufacturers . . . Maintenance Men . . . See how you benefit from these new, modern-design pillow blocks and flanged cartridges.

"Take a look at these specifications and advantages . . ."

"These brand new flanged cartridges and pillow blocks are easily installed . . . self-aligning . . . quickly serviced. You have less to do all along the line!"

- Bearing is self-aligning. Spherically ground O.D. cuts mounting time because bearing aligns self on shaft.
- Smooth running through a long service life is assured by highest quality alloy steel races and chrome alloy steel balls. Inner race is locked to shaft by two precision ground thread set screws set at 120 degrees.
- New oil-resistant seal of labyrinth design provides dirt-free lubrication chamber. Seal is integral with bearing, permitting unrestricted misalignment of bearing. Design allows excess grease to escape without danger of blowing out seal.
- Bearing is prelubricated and can be placed directly in service. Alemite fitting makes regreasing easy, convenient.
- Rigid mounting provided by solid, one-piece cast iron housing. Slotted holes in base make bolting down quick, simple.
- Both flanged cartridges and pillow blocks are available for shafts ½" to 1¼" diameter.



FREE! Send for special bulletin which tells you all about these new Pillow Blocks and Flanged Cartridges.

Name..................Position..................
Company..................
Street..................
City..................Zone........State..................

One of the world's most complete lines
71 distributors in major cities

BOSTON GEAR WORKS
93 Hayward St., Quincy 71, Mass.

BUSINESS AND SALES BRIEFS

UNTIL recently assistant sales manager of Fairbanks, Morse & Co., O. O. Lewis has been promoted to the post of sales manager. At the same time, H. L. Hilleary has been appointed assistant sales manager, L. A. Weom has been made St. Louis branch manager succeeding Mr. Hilleary and D. T. Johnstone succeeds Mr. Weom as manager of the corporation's pump division.

◆

New and expanded quarters have been provided for the Cutler-Hammer sales office and warehouse in Detroit. Located at 15427 Woodrow Wilson Ave., Detroit 3, the offices are under the supervision of E. F. Weiss.

◆

Portion of the government-owned aircraft parts plant in Chula Vista, Calif., has been leased for five years to its wartime operator the Rohr Aircraft Corp. The facilities, comprising six buildings with a floor space of 250,000 square feet, will be used for the manufacture of aircraft equipment.

◆

Chase, Parker & Co. Inc., 288-290 Congress St., Boston, have been appointed Boston area distributors for Diamond Chain Co. Inc., manufacturers of chain, sprockets and flexible couplings.

◆

According to a recent announcement, Ward Leonard Electric Co. has established a Los Angeles branch office under the direction of H. S. Eales. Located at 420 S. San Pedro St., the office and warehouse will serve all of southern California.

◆

Corporate name of the Rigid-Tex Corp., Buffalo manufacturer of textured metals, has recently been changed to Rigidized Metals Corp.

◆

Separate sales district for the state of Michigan has been announced by the apparatus department of the General Electric Co. Formerly a part of the central district, the newly constituted Michigan district will include sales offices

POWERFUL ARMS FOR MIGHTY MUSCLES

Walter Motor Truck, Model AC-VD, equipped with special 12 yard Heil Rock Body and Twin Telescopic Hoist for use in open pit iron mine handling.

GLOBE
STEEL TUBES

"MECHANICAL muscles" just don't "happen." Hydraulic pressures would be impotent without pressure-resistant channels to confine them. Mechanical tubing of adequate strength is an important part of hydraulic devices. Globe builds mechanical tubing that provides strength with light weight for hydraulic and many structural applications.

Here is another example of Globe's ability to supply tubing in a wide range of sizes, analyses, and types, for a variety of needs. And when you specify "Globe" you are sure of uniformity and quality in tubing—mechanical, pressure, corrosion resistant applications.

5024

GLOBE STEEL TUBES CO.
Milwaukee 4, Wisconsin, U. S. A.

GLOBE
TUBES

★ STAINLESS STEEL TUBES ★ PRESSURE TUBES ★ GLOBEIRON TUBING ★ GLOWELD TUBES
★ CONDENSER AND HEAT EXCHANGER TUBES ★ MECHANICAL TUBING

AL.."FINEST HEX-SOCKET SCREWS MONEY CAN BUY"
LEN.."IN A NEW DISTINCTIVE BOX"
ALLEN
ALLEN HEAD
You know what you're getting when you
BUY IN "ALLEN'S ALLEY"

Allen stands for special Allenoy steels, for complete facilities for threading by any method, for the latest forming and heat-treating techniques, for quality control, and advanced engineering. You get all these advantages in one package, if you make sure that package is the new black *Allen* package with the silver stripes.

If the shelves in your distributor's hex-socket screw section display row on row of the new, distinctive black box with the silver bands, you know you're getting *genuine Allens*, not just Allen-type hex-socket cap and set screws.

SOLD ONLY THROUGH LEADING DISTRIBUTORS

ALLEN ALLEN HEAD

Hartford 2, Connecticut, U.S.A.
NEW YORK, CLEVELAND, DETROIT, CHICAGO, LOS ANGELES

in Detroit, Lansing, Jackson, Grand Rapids and Saginaw. Headquarters in Detroit will be under the supervision of A. R. Hines.

◆

Several recent appointments have been made by the Glidden Co. Named manager of the direct sales department in Cleveland is Charles M. Dunn Jr., while Henry D. Coulton has been appointed sales manager of the Eastern direct sales division with offices in Reading, Pa. Ian L. Carmichael has been named national accounts department manager for the company's paint and varnish division with offices in Cleveland. Concurrently, announcement was made of the opening of a new paint and varnish warehouse in Norfolk, Va. serving the tidewater section of that state.

◆

Formerly Eastern regional sales manager for Brown Instruments division of Minneapolis-Honeywell Regulator Co., O. B. Wilson has been named manager of sales for the East, Southeast and Central regions. He will make his headquarters in Philadelphia.

◆

Succeeding the late C. E. Webster, T. F. Rose has been appointed manager of Timken Roller Bearing Service and Sales Ltd., Toronto, Ontario. Mr. Rose previously served as Cincinnati branch manager of the American company's service sales division.

◆

New Chrysler-Amplex plant in Detroit provides expanded facilities and latest equipment for the manufacture of Oilite bearings, machine parts and other machine components. The new manufacturing unit is located at 65th and Harper Ave.

◆

Walter A. DeLamater has been elected a vice president of the Heli-Coil Corp., manufacturers of screw-thread inserts. Mr. DeLamater has been active in the textile industry for many years and is a retired Major General.

◆

A number of recent appointments have been made in the chemical department of the General Electric Co. Among these is the naming of James W. Raynolds as sales manager of silicone products, appointment of Kenneth J. Barlow to the post of manager of sales administration for the plastics division, and appoint-

Because EXTRA CARE Goes Into The Windings

ELECTRO DYNAMIC MOTORS

are stout-hearted motors!

E.D. Drip Proof Industrial Motor. For use under ordinary industrial conditions not requiring protection from splashing liquids or from atmosphere laden with dirt or metal chips.

Unique Manufacturing Methods Now Assure You Longer Service, Greater Operating Dependability

It's true! E.D. industrial motors give you the same *extra* length of service, the same staunch *dependability* that have caused Electro Dynamic's famous *marine* units to be specified for *over 50%* of America's new ships!

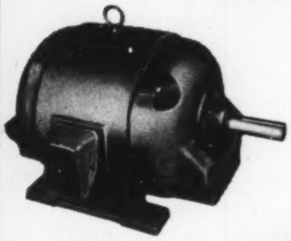
Men who know E.D. motors will tell you that it's at the windings—"the heart of the motor"—that these fine power plants achieve their great reliability and long life. The craftsmen who produce E.D. windings have long been schooled in the most exacting job a motor maker has to face—that of meeting and surpassing the rigid standards set by naval architects and engineers. The extra care and superior insulation materials required in motors for gruelling marine use are *plus qualities* inherited by the entire E.D. industrial line.

You'll realize what sturdiness and durability in a motor can mean when you see the cast E.D. frames, ribbed for extra strength, cast with feet as integral parts for greater rigidity, accurately machined to close tolerances for proper alignment.

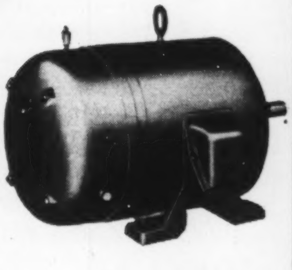
You'll be amazed that any motors can be so painstakingly made of such high-quality materials, yet be *competitively priced!*

Write today for information and literature on Electro Dynamic industrial motors. There's no obligation.

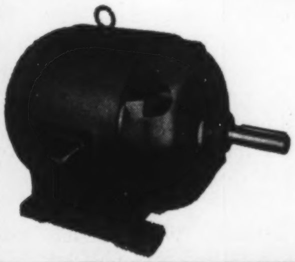
There's an E.D. ENCLOSURE for Every Installation



SPLASH PROOF
For installation where the motor is subjected to splashing liquid or hosing down for cleaning.



TOTALLY ENCLOSED
(Fan Cooled)
For use in dirt-laden atmospheres, especially where the installation requires a motor of compact dimensions.



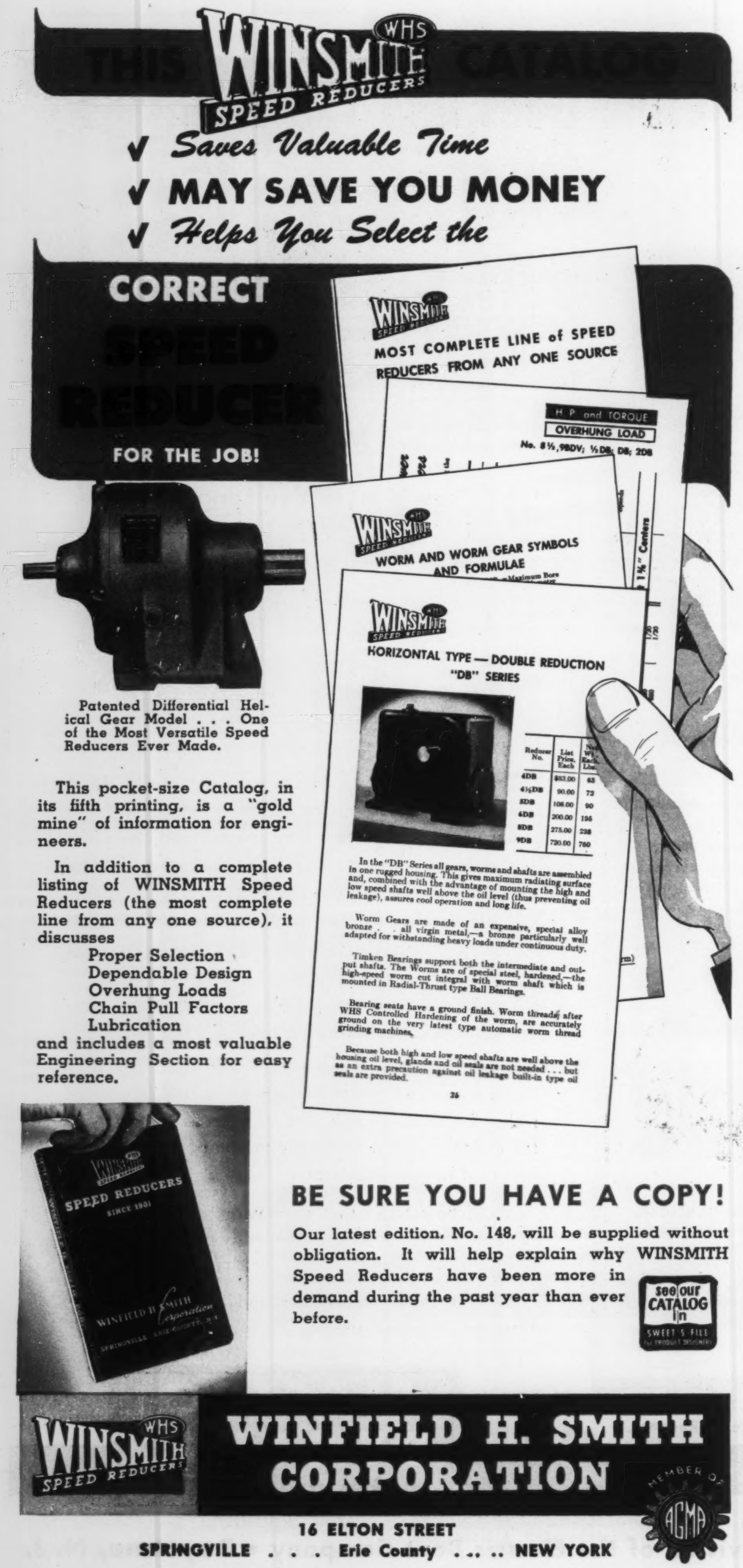
TOTALLY ENCLOSED
(Non-Ventilated)
For use in exceptionally dirty atmospheres, particularly when metallic dust is present.

Also a Complete Line of DIRECT CURRENT Motors and Generators. Literature on Request.

ELECTRO DYNAMIC

Industry is learning what marine engineers have known since 1880

ELECTRO DYNAMIC • Division of the Electric Boat Company • Bayonne, N. J.



THIS WINSMITH WHS SPEED REDUCERS CATALOG

✓ Saves Valuable Time

✓ MAY SAVE YOU MONEY

✓ Helps You Select the

CORRECT SPEED REDUCER FOR THE JOB!

WINSMITH SPEED REDUCERS

MOST COMPLETE LINE of SPEED REDUCERS FROM ANY ONE SOURCE

H. P. and TORQUE

OVERHUNG LOAD

No. 8½, 9BDV; ½DB; D8; 2DB

WINSMITH SPEED REDUCERS

WORM AND WORM GEAR SYMBOLS AND FORMULAE

WINSMITH WHS SPEED REDUCERS

HORIZONTAL TYPE — DOUBLE REDUCTION "DB" SERIES

Reducer No.	List Price, Each	Net Wt. Each, Lbs.
4DB	$83.00	63
4½DB	90.00	72
5DB	108.00	90
6DB	200.00	195
8DB	275.00	238
9DB	720.00	760

In the "DB" Series all gears, worms and shafts are assembled in one rugged housing. This gives maximum radiating surface and, combined with the advantage of mounting the high and low speed shafts well above the oil level (thus preventing oil leakage), assures cool operation and long life.

Worm Gears are made of an expensive, special alloy bronze . . . all virgin metal,—a bronze particularly well adapted for withstanding heavy loads under continuous duty.

Timken Bearings support both the intermediate and output shafts. The Worms are of special steel, hardened,—the high-speed worm cut integral with worm shaft which is mounted in Radial-Thrust type Ball Bearings.

Bearing seats have a ground finish. Worm threads, after WHS Controlled Hardening of the worm, are accurately ground on the very latest type automatic worm thread grinding machines.

Because both high and low speed shafts are well above the housing oil level, glands and oil seals are not needed . . . but as an extra precaution against oil leakage built-in type oil seals are provided.

26

Patented Differential Helical Gear Model . . . One of the Most Versatile Speed Reducers Ever Made.

This pocket-size Catalog, in its fifth printing, is a "gold mine" of information for engineers.

In addition to a complete listing of WINSMITH Speed Reducers (the most complete line from any one source), it discusses

Proper Selection
Dependable Design
Overhung Loads
Chain Pull Factors
Lubrication

and includes a most valuable Engineering Section for easy reference.

WINSMITH SPEED REDUCERS SINCE 1901

WINFIELD H. SMITH Corporation

SPRINGVILLE ERIE COUNTY, N.Y.

BE SURE YOU HAVE A COPY!

Our latest edition, No. 148, will be supplied without obligation. It will help explain why WINSMITH Speed Reducers have been more in demand during the past year than ever before.

see our CATALOG in SWEET'S FILE for PRODUCT DESIGNERS

WINSMITH WHS SPEED REDUCERS

WINFIELD H. SMITH CORPORATION

MEMBER OF AGMA

16 ELTON STREET
SPRINGVILLE . . . Erie County . . . . NEW YORK

ment of S. L. Brous as marketing manager of the chemical department.

◆

Industrial products sales division of the B. F. Goodrich Co. has become the industrial and general products division and now includes plastic products sales and production departments. Named manager of the plastics products sales department is Clyde D. DeLong who will have his office at the plastic products plant near Marietta, Ohio. Concurrently, I. N. Kimsey has been named field sales manager of the division and J. R. Thompson has been named manager of flat, conveyor and transmission belting.

◆

Los Angeles district office and warehouse of the Chain Belt Co. has been moved to new and larger quarters at 3838 Santa Fe Ave., Los Angeles 11. J. V. MacDonald will continue in charge. Two additional sales offices have been opened in other sections of the country, one in St. Louis and the other in Jacksonville, Fla. The St. Louis office, under the direction of Clarence R. Studer, is located at 8001 Clayton Rd., while the Jacksonville office is at 340 W. Church St. and directed by David B. Hill.

◆

Among other recent appointments of the Syntron Co., E. J. McIlvaine has been named junior salesman in the vibratory material handling division of the St. Louis office and A. C. Staley Jr. has been named in the same capacity in the Cleveland office. Concurrently, location of two offices have been changed: Philadelphia branch office is now at 1018 W. Lehigh Ave., and the Kansas City, Mo., office is now located in the Wirthman Bldg., 31st at Troost Ave.

◆

A number of new distributors have been added by Reynolds Metals Co. Included among these are: Hamilton Steel Co., Cleveland; A. C. Harvey Co., Boston; Levinson Steel Sales Co., Pittsburgh; Lyon, Conklin & Co. Inc., Baltimore; Potts-Farrington Co., Philadelphia; and United States Steel Supply Co., Chicago.

◆

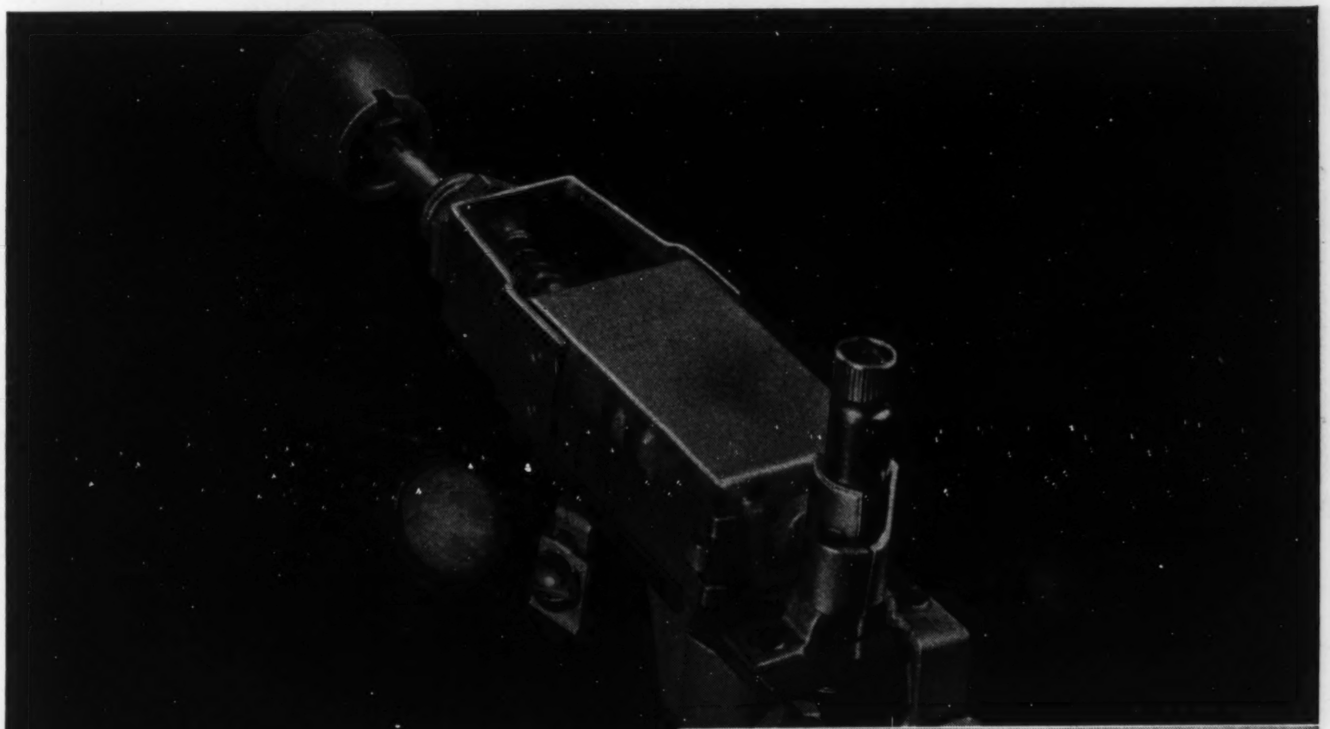
Appleton, Wis., office has been opened by the Foxboro Co., manufacturers of industrial measurement and control instruments. Office, located at 123 W. College Ave., will be supervised by Milton A. Schreiner.

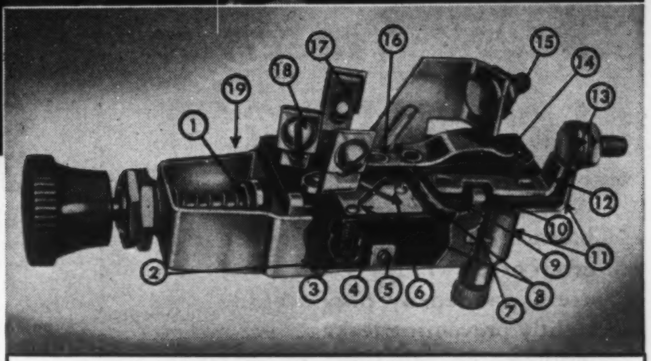
◆

Standard Transformer Co. of Warren, Ohio, has appointed Robert P. Smith as its representative for the

REVERE MATERIALS + COLE-HERSEE DESIGN ASSURE DEPENDABLE HEADLAMP OPERATION

(Sixty Percent of All Automobile Accidents Occur After Dark)





Three-Position Heavy Duty Headlamp Switch, made by Cole-Hersee Company, 20 Old Colony Ave., Boston 27, Mass.

1. Spring Backed Dustproofed Gland
2. Heavy Steel Case and Bracket
3. Four Separate Contact Springs
4. Moulded Bakelite Contact Carrier
5. Double Independent Action
*6. Heavy Gauge Phosphor Bronze Contactor
7. Interlocking Back Prevents Short Circuiting
*8. Silver Inlaid Phosphor Bronze Contacts
9. Canvas Base Bakelite
10. Six Clinching Ears
11. One Piece "Hot Wire" Conductor
12. Heavy Reinforcement and Thrust Stop
*13. Terminal Studs Welded to Conductors
*14. Heavy Gauge Phosphor Bronze Spring Contacts
15. Heavy Conductor and Thrust Stop
*16. Silver Inlaid Phosphor Bronze Contact Rivets
17. Heavy Gauge Screw Terminals
18. Shakeproof Lockwashers With Locking Tail
19. Bracket Extension To Clear Dash Obstructions

**Parts starred are made of Revere Metals*

HERE is a picture and sectional view of a device frequently used by motorists, who know nothing about it except that it has a knob and works perfectly when pushed or pulled. It is a Cole-Hersee three-position light switch: Off, Parking Lights, Headlights.

Because such a switch is so reliable and long-lived, one might suppose it to be simple. It is far from that. Its operation, however, is simple, and is protected by design and materials which foresee the conditions and contingencies of use.

Note the variety of the materials. They include steel in several types and forms, brass, phosphor bronze, canvas base bakelite, a felt washer to exclude dust, plastic, and if you include the fuse, lead and glass. In the list of features the four items starred are made of Revere Metals.

This is an excellent example of the manner in which wise manufacturers employ Revere Metals. Both they and we realize that every metal and material has its individual qualities and applications. When these are understood and chosen with full regard for conditions of fabrication and use, a fine product has been given its fundamental guarantee. It is one of the important duties of Revere Technical Advisors to collaborate in the selection of the many different Revere Metals. If you would like to obtain the benefits of this service, get in touch with the nearest Revere Office.

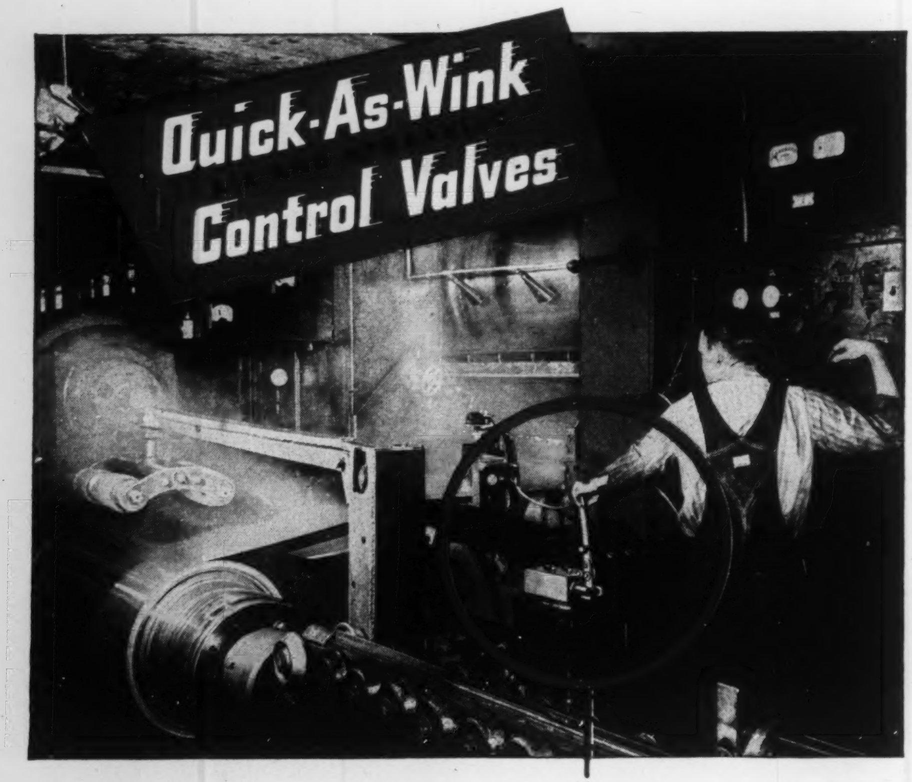
REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801
230 Park Avenue, New York 17, New York

• • •

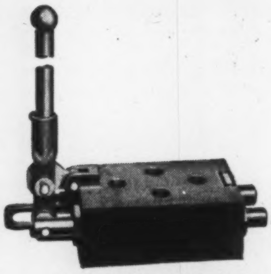
Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; New Bedford, Mass.; Rome, N. Y.—Sales Offices in Principal Cities, Distributors Everywhere.



For a maximum of long, efficient, trouble-free service

● Quick-As-Wink Valves are high quality controls designed and built to meet the most exacting requirements. All operating parts are in pressure balance eliminating any tendency to creep or crawl. The U-shaped packers are expanded by pressure and seal tightly preventing leakage. There is no lapping—no grinding—no metal-to-metal seating. Every valve is precision made and individually tested to its full pressure rating before being shipped.

Furnished in hand, foot, pilot, solenoid and diaphragm operated designs for controlling all types of air and hydraulic equipment. Let us work with you on your requirements!



Quick-As-Wink Lever Operated Hydraulic Valves

The HS-551-N4 pictured above is a neutral position 4-way valve for controlling double acting cylinders. It has a machined steel housing, chrome plated and polished stainless steel plungers, and renewable metal rings to take the impingement of the liquid flow preventing wear on the U-packers. Used for oil or water up to 3500 P.S.I. and 150° F. Other valves available for pressures up to 5000 P.S.I.;—but send for a catalog today and get *full* details about the *complete* line.

Quick-As-Wink Control Valves

THE HIGHER THE PRESSURE THE TIGHTER THE SEAL

Manufactured by C. B. HUNT & SON, Inc., *Salem, Ohio.*

Engineering and Sales Representatives in the Principal Cities

State of Florida. Mr. Smith is located at 123 W. Beaver St., Jacksonville.

◆

Formerly manager of sales for the wire and cable division of the General Electric Co., Murray H. Owen has been appointed to the staff of the manager of sales of the construction materials department.

◆

Change of address has been announced for the Pacific division of the Parker Appliance Co. Located at 5827 W. Century Blvd., the division has increased facilities.

◆

Harry D. Sweeney has been appointed sales manager of welded products for the American Manganese Steel Div. of American Brake Shoe Co. Mr. Sweeney formerly held the post of sales engineer.

◆

Change of name of the F. A. Smith Mfg. Co. Inc. to Fasco Industries Inc., announced in the February issue of MACHINE DESIGN, has been accompanied by no change in corporate structure, officers, directors or policies according to a recent statement by H. P. Toppin, president of that corporation.

◆

New Michigan branch office of Gits Bros. Mfg. Co. will be managed by Frank A. Kovarik, general sales manager.

◆

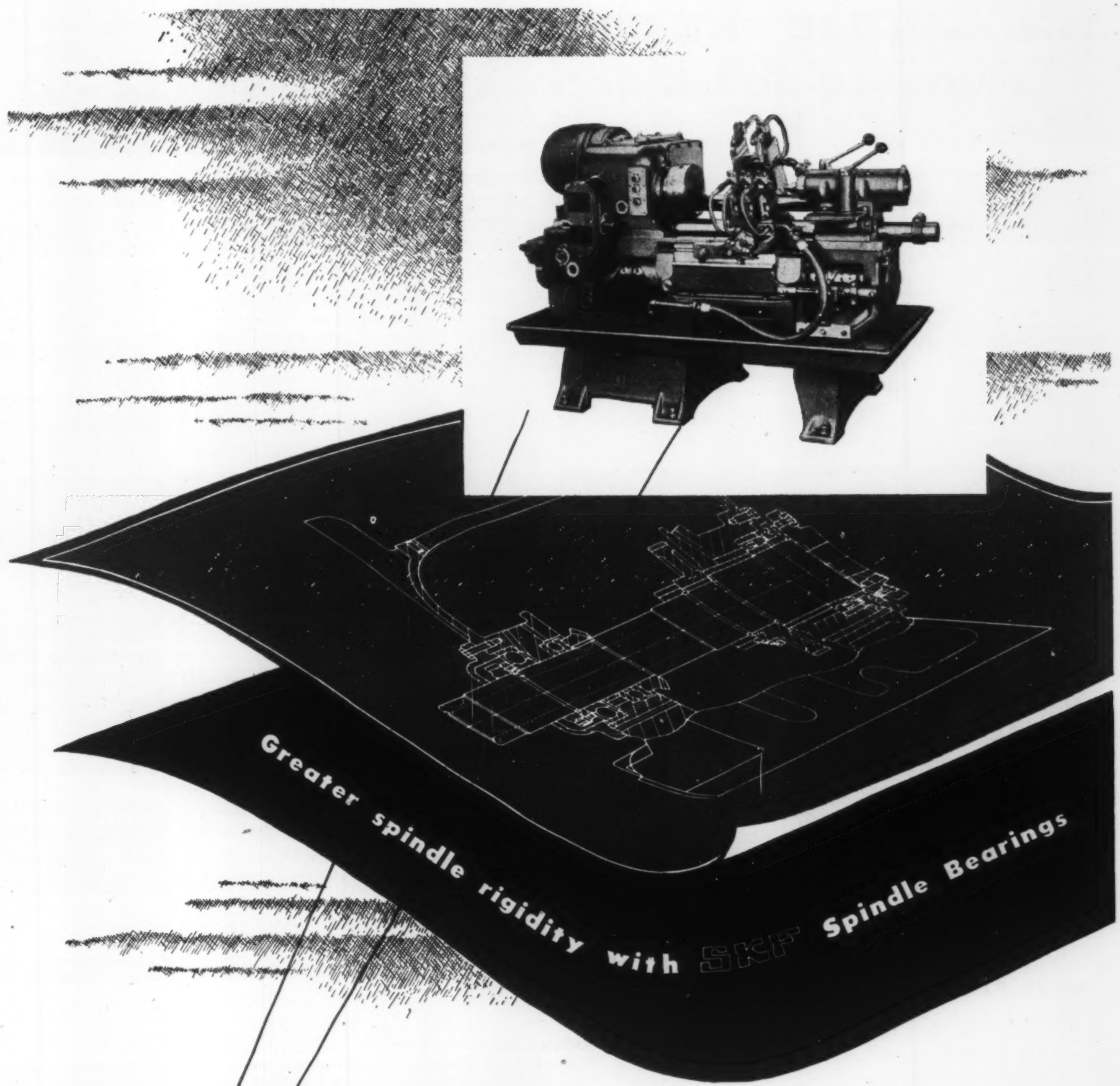
Succeeding Roger Schofield, Clyde Moyer has been appointed Philadelphia district representative of Baldwin Locomotive Works, testing equipment department. Mr. Schofield has been transferred to Baldwin's transportation section.

◆

Partnership known as the Euclid Machine & Tool Co. has been dissolved and a new corporation, Euclid Universal Machine Inc., has been formed for the manufacture of speed reducers and other products. The address remains the same: 15002 Woodworth Rd., Cleveland 10. Officers of the corporation are: Fred Sneller, president, and Clifford F. Sneller, executive secretary and treasurer.

◆

According to a recent release Charles T. Morgan has been appointed New England sales representative of Sperry Products Inc. He will be responsible for sales development of marine and industrial applications of Sperry hydraulic remote controls and ultrasonic instruments.


Greater spindle rigidity with SKF Spindle Bearings

A couple ten-thousandths play . . . radial or end . . . can be the difference between "Reject" and "OK". That's why Jones & Lamson wanted a spindle design that was as rigid as possible.

Here's how SKF engineers designed the spindle: A double row cylindrical roller bearing at the spindle nose—for maximum radial rigidity. A thrust bearing opposed by a radial ball bearing at the rear—giving axial rigidity

9 QUALITY POINTS OF SKF SPINDLE BEARINGS

- **Maintained spindle accuracy.**
- **Radial and axial loads absorbed by separate bearings resulting in maximum radial and axial rigidity.**
- **Rigid support of inner ring—eliminating creep.**
- **Press fit in housing supports outer ring.**
- **Positive control of internal radial clearance.**
- **Lapped rollers of "Gauge Makers" accuracy.**
- **No bearing adjustments required for a wide range of speeds, feeds and depths of cuts.**
- **Minimum "camming" action.**
- **Low friction—low operating temperature.**

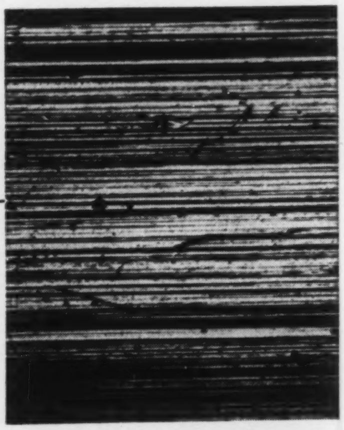
Also manufacturers of quality	**Ball and Roller Bearings** **Pillow Blocks** **Red Seal Bearings** **Balls**

An SKF Spindle Design engineer can help you with your machine tool bearing problems. Give him a call, or write: SKF Industries, Inc., Philadelphia 32, Pa. 6608

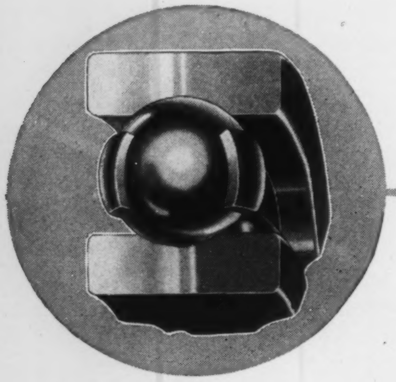
***MACHINE TOOL BEARINGS ENGINEERED BY* SKF**

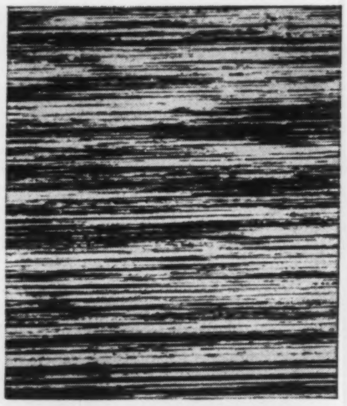
YOU CAN SEE THE DIFFERENCE
IN HOOVER HONED RACEWAYS

The photographs reproduced at the right are magnified one hundred times, so that you can see the difference between ground, polished and honed raceways. Hoover is America's only ball bearing with honed raceways. The process and the special machines for the honing operation, are exclusive, patented, Hoover developments. Hoover honing goes far beyond grinding and polishing to produce a surface that represents the closest approach to absolute perfection obtainable on a commercial basis.



GROUND RACEWAY SURFACE
(Photographed at 100 Magnifications)





POLISHED RACEWAY SURFACE
(Photographed at 100 Magnifications)

HONED RACEWAY FEATURES

Summed up Hoover honing provides the following results . . .

1. Extreme quietness.
2. Increased load capacity.
3. Extended life.
4. Reduced end play (axial displacement).
5. Reduced radial displacement.
6. Permanence of fit up.
7. Increased resistance to Brinneling.
8. Uniformity of fit up.
9. Freedom from vibration.
10. Perfection of dynamic balance.

HONED RACEWAY SURFACE
(Photographed at 100 Magnifications)

A request on your Letterhead will bring a copy of the Hoover Engineering Manual

HOOVER
AMERICA'S ONLY BALL BEARING
WITH HONED RACEWAYS

HOOVER BALL AND BEARING CO., ANN ARBOR, MICHIGAN

Meetings and Expositions

Mar. 28-30—

Society of Automotive Engineers Inc. Transportation meeting to be held at Statler Hotel, Cleveland. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

Apr. 5-6—

Metal Powder Association. Fifth annual meeting and exhibit to be held at the Drake Hotel, Chicago. Robert L. Ziegfeld, 420 Lexington Ave., New York 17, N. Y., is acting secretary.

Apr. 11-12—

American Institute of Electrical Engineers. Conference on the industrial application of electron tubes to be held at Statler Hotel, Buffalo. H. H. Henline, 33 West 39th St., New York 18, N. Y., is secretary.

Apr. 11-13—

American Society of Lubrication Engineers. Fourth annual convention and second annual lubrication exhibit to be held at Hotel Statler, New York. W. F. Leonard, 343 South Dearborn St., Chicago 4, Ill., is secretary.

Apr. 11-13—

Society of Automotive Engineers Inc. Aeronautic and air transport meeting to be held at Hotel New Yorker, New York. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

Apr. 11-15—

American Society for Metals. Western metal congress and exposition to be held at Shrine Civic Auditorium, Los Angeles. W. H. Eisenman, 7301 Euclid Ave., Cleveland 3, Ohio, is secretary.

Apr. 18-20—

Midwest Power Conference sponsored by the Illinois Institute of Technology to be held at Sherman Hotel, Chicago. Dr. E. R. Whitehead, 3300 South Federal St., Chicago 16, Ill., is conference secretary.

Apr. 19-20—

The Magnesium Association. Annual spring meeting and product ex-

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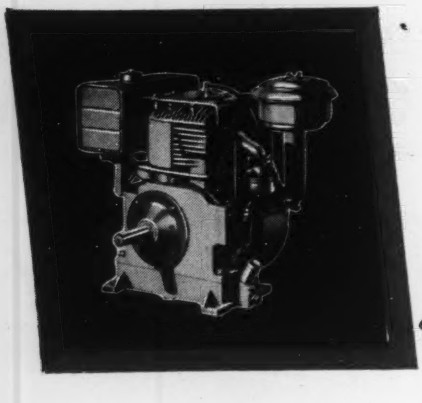

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hibit to be held at the Edgewater Beach Hotel, Chicago. T. W. Atkins, 30 Rockefeller Plaza, New York, N. Y., is executive vice president.

Apr. 25-28—

Southern Machinery and Metals Exposition to be held at the Municipal Auditorium, Atlanta. Michael F. Wiedl, 267 E. Paces Ferry Road, N.E., Atlanta 5, Ga., is managing director.

Apr. 25-29—

American Society of Mechanical Engineers. Oil and gas power division conference to be held at Hotel Sherman, Chicago. C. E. Davies, 29 West 39th St., New York 17, N. Y., is secretary.

May 2-4—

American Society of Mechanical Engineers. Spring meeting to be held at Hotel Mohican, New London, Conn. C. E. Davies, 29 West 39th St., New York 17, N. Y., is secretary.

May 2-5—

American Foundryman's Society. 1949 Foundry Congress to be held in St. Louis. Additional information may be obtained from headquarters of the society at 222 W. Adams St., Chicago 6, Ill. William W. Maloney is secretary.

May 2-13—

British Industries Fair to be held at Earl's Court and Olympia, London; and at Castle Bromwich, Birmingham, England. Additional information may be obtained from British Information Services, 30 Rockefeller Plaza, New York 20, N. Y.

May 10-13—

American Management Association. 18th annual national packaging exposition to be held in the Public Auditorium, Atlantic City, N. J. Henry J. Hawlett, 330 West 42nd St., New York, N. Y., is secretary.

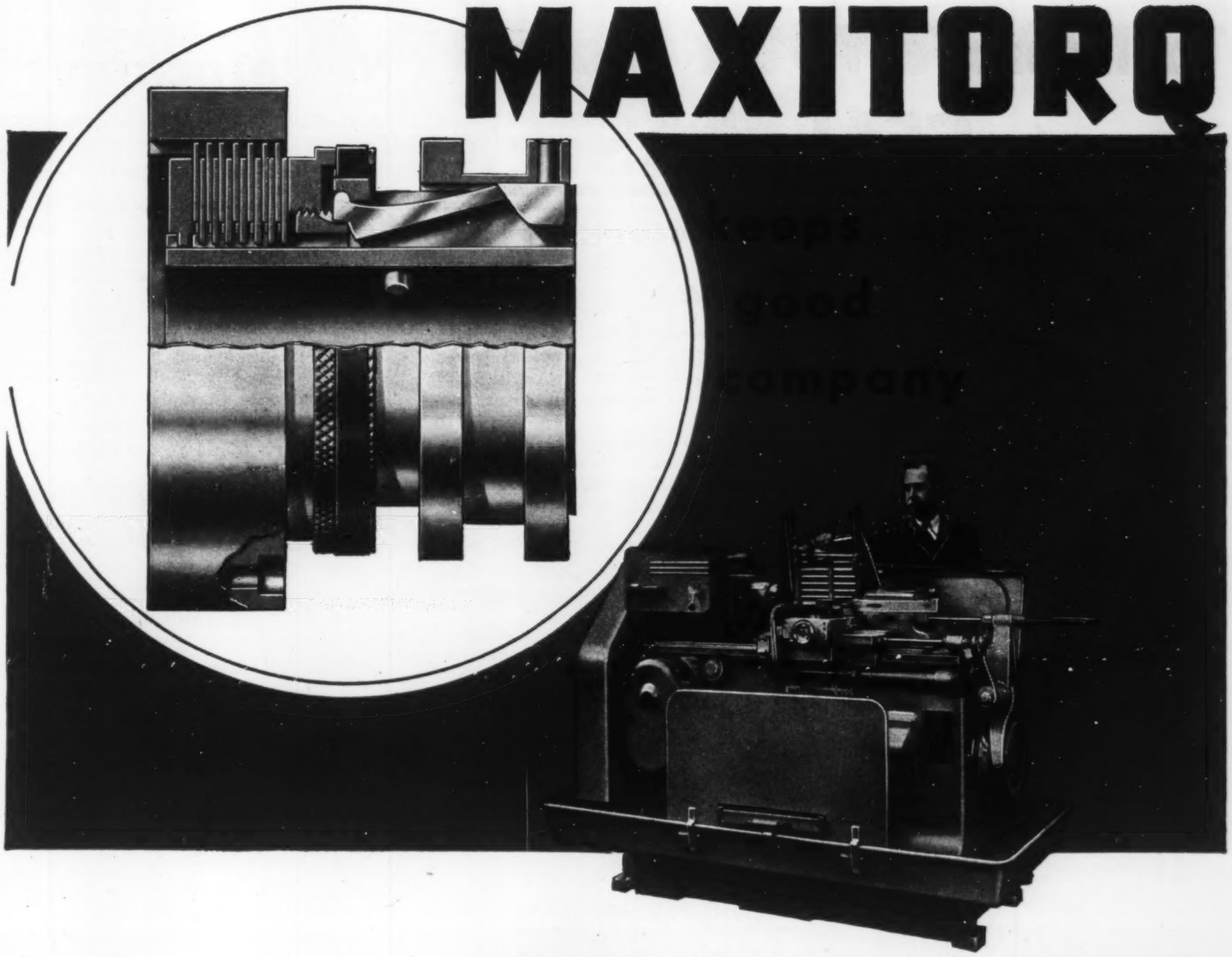
May 12-13—

Instrument Society of America. Fourth annual spring meeting to be held at the Royal York Hotel, Toronto, Canada. Richard Remback, 1117 Wolfendale St., Pittsburgh 12, Pa., is executive secretary.

June 5-10—

Society of Automotive Engineers. Summer meeting to be held at French Lick Springs Hotel, French Lick, Ind. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

MAXITORQ



Another leading machine tool builder . . . Pratt & Whitney Division, Niles-Bement-Pond Co., has selected the Maxitorq Floating Disc Clutch as original equipment in their 1¼x16 Model C Automatic Lathe. It is used in the feed drive for obtaining rapid traverse return of the carriage at the completion of each cut. For this fast feed, the single clutch operates directly from the motor . . . with the cutting feed drive declutched. Clutch operates once each cycle.

Maxitorq is mechanically right for machine tools, for industrial trucks, cranes, packaging and labeling machines, textiles, printing, and a host of other equipment within its capacity . . . to 15 H. P. @ 100 r.p.m.

The design is neat and compact. No tools are needed for assembly, adjustment or take-apart. Completely assembled ready to slip onto a shaft. Maxitorq Separator Springs keep discs apart in neutral . . . no heating. Wet or dry types, single or double. Write for engineering data.

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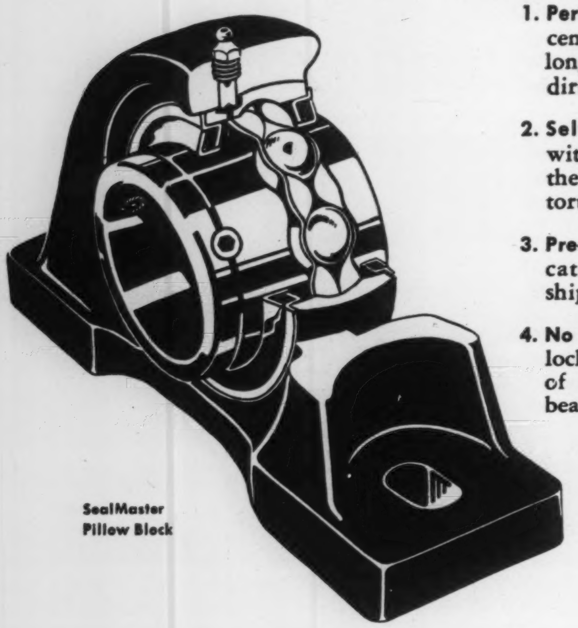

SealMaster Pillow Block

1. **Permanently Sealed**—Patented centrifugal flinger seal prolongs bearing life by excluding dirt and retaining lubrication.
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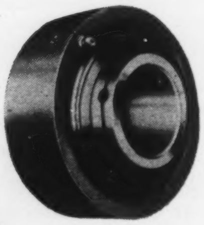
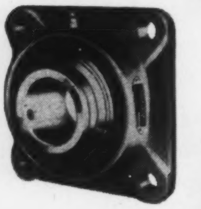
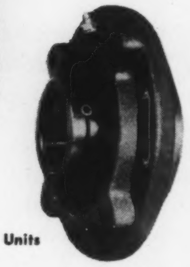
3. **Pre-Lubricated**—Factory-lubricated, all SealMasters are shipped ready for installation.
4. **No Housing Wear**—Patented locking pin prevents rotation of outer race and positions bearing for re-lubrication.
5. **Quiet Operation**—is assured by combination of deep-grooved lapped ball races and balls and felt-lined seals.



1. Cartridge Units



2. Flange Units



3. Flange Cartridge Units

It is the exclusive combination of design features that has made SEALMASTER ball bearing units essential on all kinds of industrial equipment. SealMasters are improving the performance of such products as air conditioning equipment, textile machinery, conveyors, road machinery, machine tools, oil field machinery, farming equipment and many others. Engineering data, dimensions and load ratings on the SEALMASTER line furnished on request.

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ADDRESSER. Low-cost, hand-operated machine uses master tape and colorless fluid to address 20 envelopes or cards per minute. Printing is from carbon impressions typed on paper strip. Machine stores in box 12 by 9 by 7 in. G. G. Sampson Associates, New York.

TAG ADDRESSER. Stencils 150 tags or labels per minute. At least 5000 prints from standard stencil carrying up to 9 lines. Hand operated; fully adjustable for various size tags or labels. Weber Addressing Machine Co., Mount Prospect, Ill.

Commercial

FLOCK AGITATOR. Provides even flow of flock to spray gun. Electrically driven unit keeps fibrous material dry and in suspension for delivery to gun nozzle. Flock gun uses 4½ cfm of air at 30 psi. Unit used to apply flock in decorative and sound deadening applications, automotive trunk and glove compartment interiors and on fabrics. Binks Mfg. Co., Chicago.

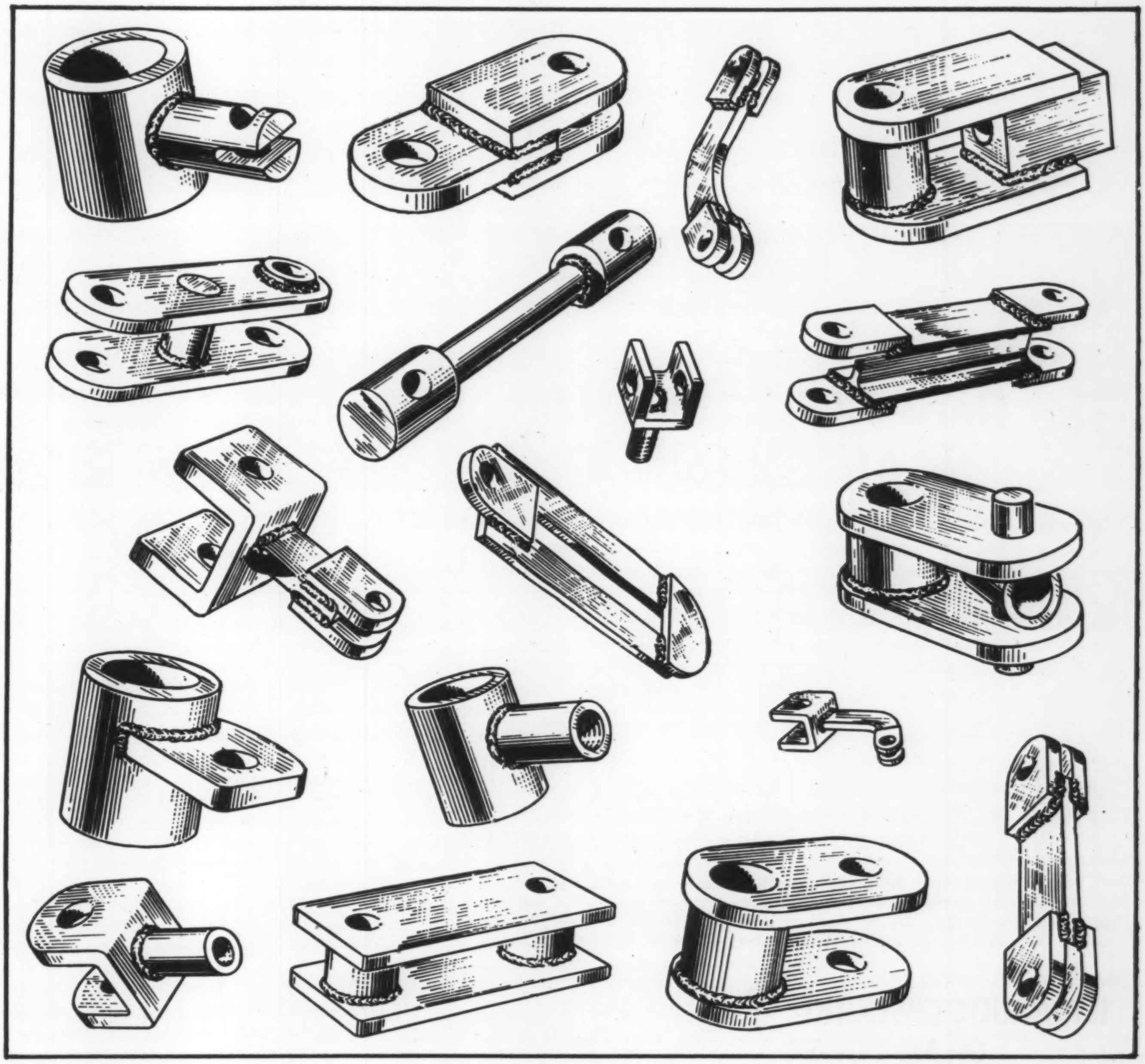
POWER LAWN MOWER. Cuts 3 acres per day. Cutting width, 19 in. Powered by 0.8-hp gas engine; cutting reel is chain driven from clutch. Includes ball-bearing, rubber-tired wheels and tubular steel handle. Coldwell-Philadelphia Lawn Mower Co., Newburgh, N. Y.

ELECTRIC LABEL PASTER. Portable. Handles labels of paper, light cardboard or cloth to 6-in. wide. Feed and glue rollers readily removable for inspection and cleaning. Accurate, adjustable control of glue application by use of dual glue rollers instead of usual scraper knife. Thermostat regulates temperature of glue; unit powered by 1/20-hp motor from lighting circuit. Scientific Filter Co., New York.

SCREW CAPPING MACHINE. Handles plastic and metal caps to 70 mm. Automatic hopper and chute assembly for delivering caps to chuck. Adjustable tension device prevents breakage of plastic caps when tightened. Tite-Cap Machine Co. Inc., New York.

POWER MOWER. Whirling blade type cuts 17-in. swath. Powered by gas engine mounted on 4-wheel chassis. Cutting height adjustable from ½ to 3½ in. Fold-back steel guard in front and swinging tail-gate

How to Build Links at Less Cost with Arc Welding



The links and clevises shown above are typical of the many different kinds of machinery component parts that are being fabricated today at less cost with arc welding than with other methods. Welded steel parts like these are decidedly stronger and more rigid, yet require considerably less material to build. Amazingly simple in design, welded steel machinery parts can be produced efficiently in all quantities using steel plate and standard mill shapes and forms.

More detailed data on the design of links and other machinery parts for arc welding is contained in the "Procedure Handbook of Arc Welding Design and Practice." Price $1.50 postpaid in the U.S.A., elsewhere $2.00.

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Mechanically operated models are equipped with an operating lever which works from any angle in any plane. It may be operated by hand or foot, or may be linked mechanically with any moving element.

Electrically operated models are designed for electrically interlocked equipment.

Bellows Air Motors are available in bores of 1¼", 2½", 3⅝" and 4½", and in any stroke length. They can be mounted in any position.

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guard in rear protect operator. Sensation Mower Inc., Ralston, Nebr.

Communications

Marine Radiotelephone. Provides 2-way communication between ships and shore. One receiver with 10 pretuned frequencies normally provided; 2 additional receivers can be added to give 30 transmitting frequencies. 250-watt equipment covers 10 marine service bands between 2100 and 18,000 kc. Western Electric Co. Inc., New York.

Domestic

Wringer Washing Machine. Activator and pump controls relocated at hand height for ease of operation. Wringer can be stopped by slight push or pull on wringer itself. Friction-drive, impeller type pumps empty tubs in 2 min. General Electric Co., Bridgeport, Conn.

Hand Wringer Washer. Tub capacity, 4 lb. Hand-cranked wringer swings over sink or stationary tubs. Enamel tub, aluminum agitator, casters, gravity drain hose, and self-adjusting 10-in. rolls included. Taylor Corp., Alliance, Ohio.

Automatic Washer. Portable, rectangular, top-opening machine will automatically wash, rinse and damp-dry 8-lb of clothes, clean itself out, and shut off. All water connections made with rubber hose; water temperature lever controlled. General Electric Co., Bridgeport, Conn.

Electric Refrigerators. Both 8 and 10 cu ft combination refrigerator-freezer units with individual doors for each compartment. Wraparound cabinet construction. Features include butter conditioners, stainless steel adjustable shelves providing for large objects and bottle storage. Hotpoint Inc., Chicago.

Earthmoving

Dump Wagon. For bottom dump hauling; 10 by 10-ft bowl carries 27 yd or 35 tons at 30 mph. Powered by 240-hp engine, has multiple-disk, 4-wheel air brakes. Dumping action permits controlled ejection or doors can be opened to full bowl size. Drive tires take 51 per cent of loaded weight; power-proportioning differential channels power to wheel on firmest footing. R. G. LeTourneau Inc., Peoria, Ill.

Heating and Ventilating

Air Circulator. Ceiling mounted; suitable for room having 280 sq ft floor space or less. Two 12-in. cast aluminum propellers direct air upwards against ceiling at high vel-

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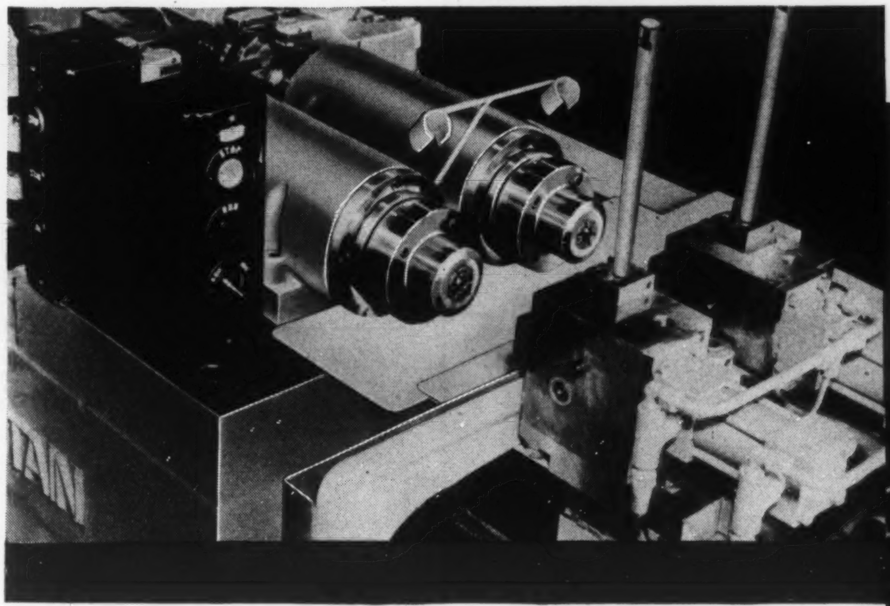
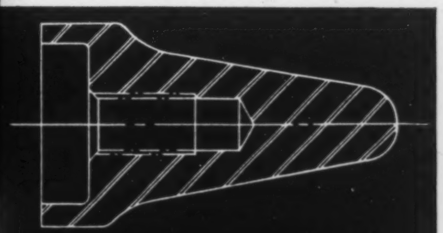
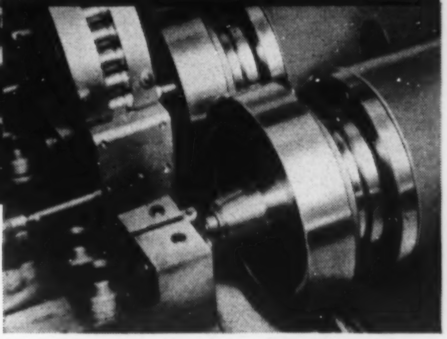


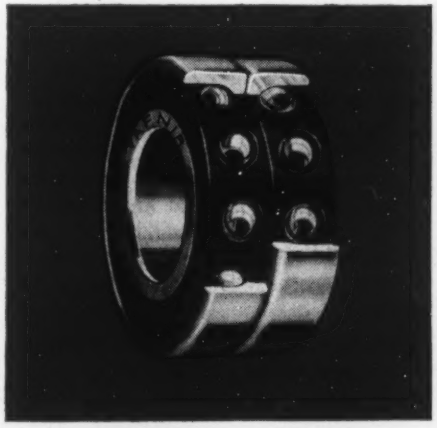


An example of contour boring with New Britain Precision Contour Boring and Turning Machine.



New Britain calls on ball bearings to "hold it"

This new cam actuated Precision Contour Turning and Boring Machine is slashing costs of second operation work by holding tolerances to incredible limits and stepping up spindle speeds as high as 7500 r.p.m. A typical performance . . . .0001 limit on size from end to end on valve guides, .0002 limit on concentricity and .0006 limit from piece to piece. Production rates are jumped from 180 to 300 pieces on one job and to as high as 1800 pieces an hour on another. At such speeds and tolerances, spindles, and particularly spindle bearings, have a real holding job.



Spindle "truth" that's hard to believe

If there's any deviation of this spindle at top speeds, you'd have a hard time finding it. But New Britain's designers modestly claim only a quarter of a tenth at 7500 r.p.m., generously give much of the credit to Fafnir Super-Precision Ball Bearings. At the work end equal length spacers between bearings increase rigidity. The rear pair is "floating".

Name your tolerance and get it with Fafnir Super-Precision Ball Bearings

These super-precision ball bearings, pioneered by Fafnir, are the aristocrats of ball bearings. Instead of the customary precision grade, these bearings are made to the highest industry approved tolerances. Duplexing matched pairs and preloading to precise limits reduce deviation at high speeds, laterally and axially, to practically zero.

An ATTITUDE and an APTITUDE

What Fafnir offers you is more important than any particular ball bearing. It's an attitude and an aptitude . . . a way of looking at ball bearings from where you're sitting . . . an aptitude for doing just what you'd like done about it, gained from solving the bearing problems of not just one or two industries but of all industries. The Fafnir Bearing Company, New Britain, Conn.

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ocity providing continuous air movement in room. Fan speeds; 700, 1300 and 1600 rpm. Overall diameter, 14 in.; height, 10 in. Reynolds Electric Co., Chicago.

BUILDING HEATING CONTROL. Provides automatic control of night set-back of building temperatures. Installed outside building, unit is set at time building is to be warm in morning. Wired into regular room thermostat circuit, equipment anticipates heat requirements of building, changing time heating starts to suit outside temperature. On extremely cold nights building is held at daytime level all night. Weather Controls Division of Automatic Devices Co., Chicago.

WINDOW FAN. Quiet operation obtained by patented method of motor-propeller hook-up which absorbs motor hub noise. Available in 12, 16 and 20-in. models. Meier Electric & Machine Co., Indianapolis.

CIRCULATING FAN. For wall, floor or table-top use. Three speeds provide air delivery of 7000, 5400 and 3800 cfm from 24-in. fan. Powered by ¼-hp induction motor; adjustable for 0, 45, or 90-degree oscillation; and will tilt from vertical to 22½ degrees below horizontal. G-M Laboratories Inc., Chicago.

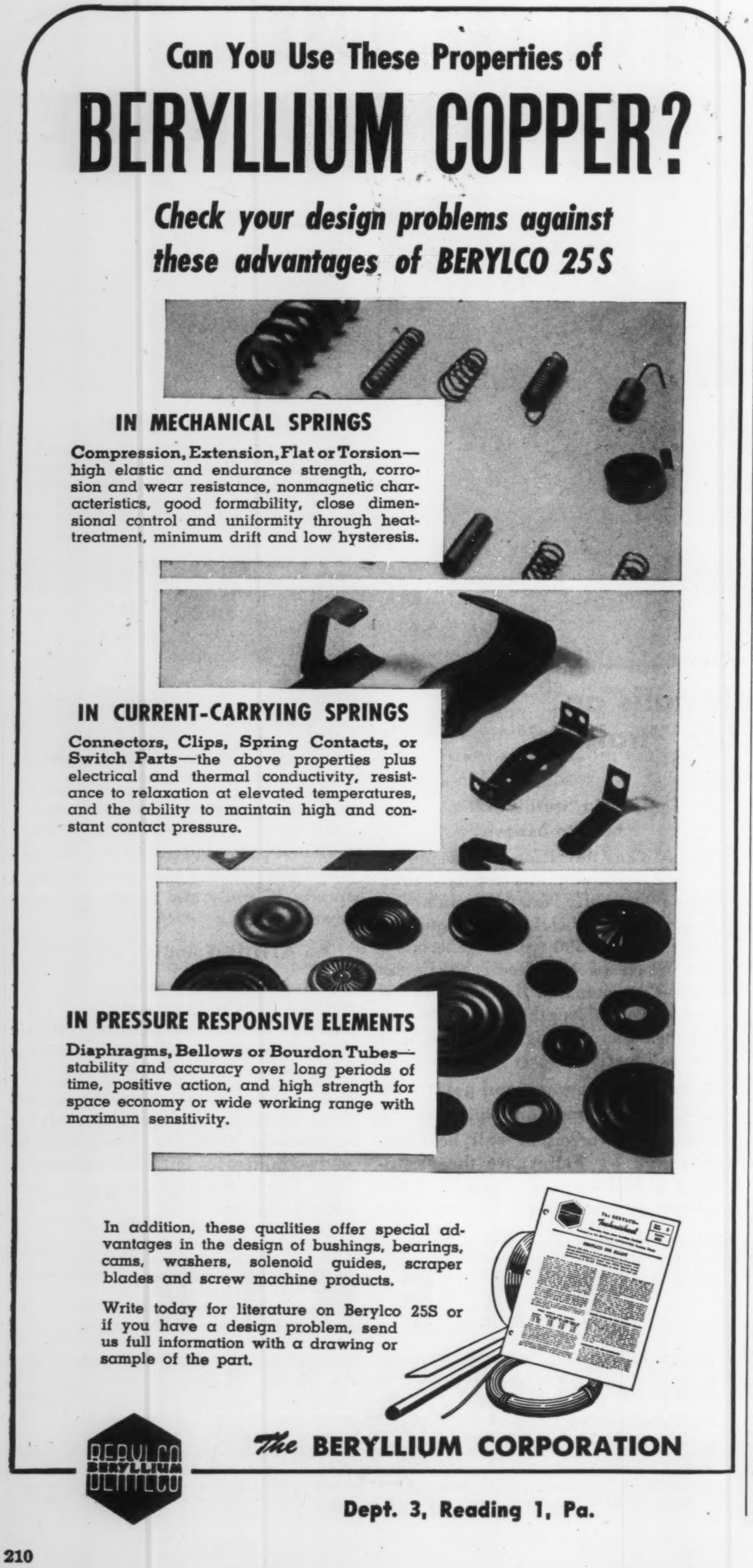
Industrial

ROTO-FINISH MACHINE. Octagonal cylinder fitted with door on each of eight sides. Parts fixed to back of each door presenting surfaces to be finished to processing mass. Doors either unlined or rubber lined. Includes magnetic brake, forward and reverse switch, and optional automatic timer. The Sturgis Products Co., Sturgis, Mich.

CRANKSHAFT CHECKING MACHINE. Checks for size and out-of-round. Five main bearings checked simultaneously using 3 air-jet gages on each bearing. Seal diameter and width of rear main bearing also checked automatically. Diameter of crankpin and radius of cheeks checked manually with air gages. The Sheffield Corp., Dayton, Ohio.

DRYING OVEN. For rapid drying of laboratory samples. Drying space; 8-in. diameter, 6-in. height. Power required, 2800 watts at 115 or 230 volts. Motor-driven fan forces air, automatically held at any temperature between 150 and 350 F, past electric heating elements. Overall height of unit, 29 in. Harry W. Dietert Co., Detroit.

AUTOMATIC BURNER. For firing boilers at capacity of 100 hp and up. Package unit includes fuel-oil pumping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INDUCTION HEATER. Delivers 750 2½ by 3 15/16-in. steel forging blanks per hour heated to 2200 F. Scale-free heating reduces rejects, reduces down time to clean dies. Blanks chute-loaded into machine, feed into heating coil and out discharge end by hydraulic pusher. Fully automatic timing. Power supplied by 960-cycle, 700-kw motor generator unit. Ajex Electrothermic Corp., Trenton, N. J.

Manufacturing

HYDRAULIC PRESS. Capacity, 125 tons. Hand, air or electric controlled models with 8-in. stroke; additional 8-in. adjustment available by auxiliary screw type ram. Air models use 90 or 145-psi air. Width between press uprights, 48 in.; distance between table channels, 12¼ in. By-pass relief valve prevents overextending ram; safety valves on air and electric models guard against overload. Drake Engine Co., Grand Haven, Mich.

HAND BENDER. Portable. Cold bends copper, aluminum, brass, and mild steel bar and strip from ⅛ to ½-in. thick and up to 6-in. wide. Makes bends up, down, sideways, and twists; has positive set-up for duplicate bending. Winfield R. Scott, Newark, N. J.

BLAST CLEANING MACHINE. Abrasive material down to 5000 mesh suspended in liquid and ejected by compressed air through blast nozzle. Suitable for deburring, finishing threaded sections, surface finishing and lubrication control, removal of directional grinding lines or heat treat scale, and in preparation of surfaces for plating or painting. Many finishes and uses possible by varying particle size and hardness, air pressure, distance of gun from work, or liquid-abrasive ratio. Cabinets 30 by 36, 36 by 48, 48 by 60, and 60 by 72 in. Pangborn Corp., Hagerstown, Md.

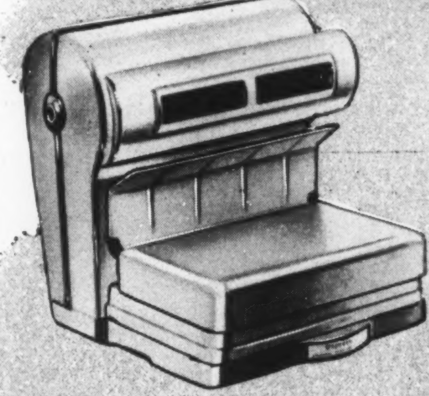
PRESS. Capacity, 75 tons. For accurate and continuous production of stampings. Welded steel construction. Barrel type adjusting screw with one piece Pitman. Air counterbalancing reduces shock of "break-through." Includes variable speed drive and provision for installation of die cushions. Federal Machine and Welder Co., Warren, Ohio.

INJECTION MOLDING MACHINE. For plastics and nylon. Speed of 600

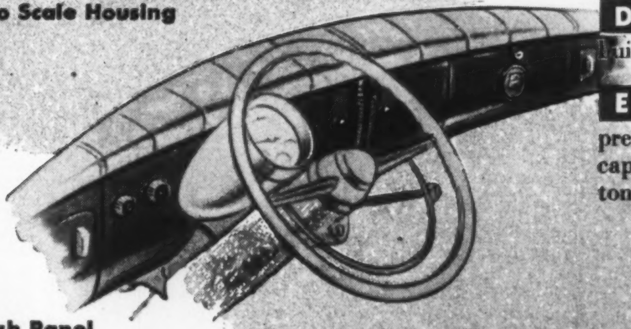
GENERAL AMERICAN MOLDS PLASTICS FOR AMERICA'S LEADING INDUSTRIES

Designed by Egmont Arens

Motorola Radio-Phonograph Cabinet



Toledo Scale Housing



Nash Dash Panel

Perhaps plastics can improve your product or some part of your product. Plastics can often add new beauty and sales appeal ... cut costs ... speed production ... perform many functions more efficiently. Consult General American about your plastics problems.

CUSTOMERS Leaders in these industries: Automotive, furniture, washing machine, refrigerator, radio, television, industrial specialties, electrical appliances.

PRODUCTION General American produces parts and products as small as screw cap pilot lights and as large as complete television cabinets. General American's engineers are constantly developing practical, new applications for plastics.

SPECIAL SERVICES Facilities for assembling of parts and products, painting and special handling wherever necessary.

DIES Dies may be supplied by customers or built in General American's complete die shops.

EQUIPMENT Large batteries of high speed presses, including injection presses of 2 to 48 oz. capacity and compression presses from 100 to 2000 tons (with 71" x 74" platen areas).

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Here's a beer cooler, designed to hold ice and water, catch beer foam, and look attractive. Naturally it must have a corrosion-resistant, indestructible, easy to clean surface, with negligible water absorption, and must not warp or distort hot or cold. All these things at lower cost! That's why it's molded in one piece of gleaming black Ace hard rubber.

Your designs too may profit from the distinctive advantages of the hard rubber or plastics compounds molded or extruded by Ace—for corrosion resistance is only *one* of many big reasons for selecting Ace. If you would like to know more about these Ace materials—where used, properties, design hints, etc.—just write on your company letterhead for the new 60-page Ace Handbook.

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machine cycles per hour possible with 4-oz machine. Central die adjustment, patented toggle links, large adjusting screw and semiautomatic operation are featured. Applies pressures to 20,000 psi. Lester-Phoenix Inc., Cleveland, Ohio.

Metal Parts Analyzer. For nondestructive metallurgical examination or sorting of small parts. Operates on core loss principle. Will sort or check parts on basis of structure, hardness, case depth, and in some cases stress concentration. Power consumption on 115-volt, 40/60 cycle current, 70 watts. J. W. Dice & Co., Grand View-on-Hudson, N. Y.

Metalworking

Adjustable Drilling Head. With 2 or 3 spindles for equal adjustment in line; 3, 4, 5, or 6 spindles for equal adjustment on bolt circles. Drill capacity, 0 to 1½-in. No drill overhang; gear driven spindles needle bearing mounted. Errington Mechanical Laboratory, Inc., Staten Island, N. Y.

Tracer-Controlled Lathe. Dual-purpose machine can be used for standard work or will automatically duplicate from round or flat templates. Reproduction of multiple diameter shafts, grinding necks, tapers, chamfers, curved contours as well as similar boring operations are automatically performed. Hydraulic tracer control shifts to standard lathe operation by turning 2 valves and 1 switch. Lodge & Shipley Co., Cincinnati.

Dual-Ram Broaching Machine. For surface broaching. Hydraulically operated, electrically controlled. Can be set for automatic continuous cycle, semiautomatic or single cycle. Forward or reverse jog cycle has ram and platen movements interlocked to prevent accidental damage to broach or parts. Available in 6 to 25-ton sizes with strokes from 42 to 66 in. Colonial Broach Co., Detroit.

Boring Machine. For rough boring railroad car wheels or other similar large forgings and castings. Two workpiece stations on hydraulically operated shuttle slide. Hydraulic clamping. Tool speeds, 80 to 240 rpm; feed speeds, infinite. Max stroke, 14 in. Fully automatic operation. Snyder Tool & Engineering Co., Detroit.

Milling Machine. Horizontal, plain type for heavy-duty production work. Capacity: vertical feed, 18¾ in; longitudinal feed, 28 in.; cross feed, 12 in. Spindle speeds from 50 to 2000 rpm; feeds down to ⅜-in. per min. Spindle driven by

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offers 5 metals to meet every requirement . . . .

You don't need to get along with tubing that is "almost good enough" when you specify TITEFLEX. For you have your choice of FIVE metals for the innercore—brass, bronze, monel, inconel, and stainless—to satisfy all specifications for temperature and corrosion resistance. For example, the top working temperatures of tubing made from these metals are as follows:

Brass	250° F.
Bronze	325° F.
Monel	800° F.
Stainless	800° F.
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The latest edition of Titeflex Catalog No. 113 will give you more complete information on these materials, as well as other useful facts about TITEFLEX, the *All-metal* flexible tubing. Write for your free copy today.

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Titeflex
All-Metal Flexible Tubing

For "*Trouble Free*" Service Simplicity Engineering Company Specifies...

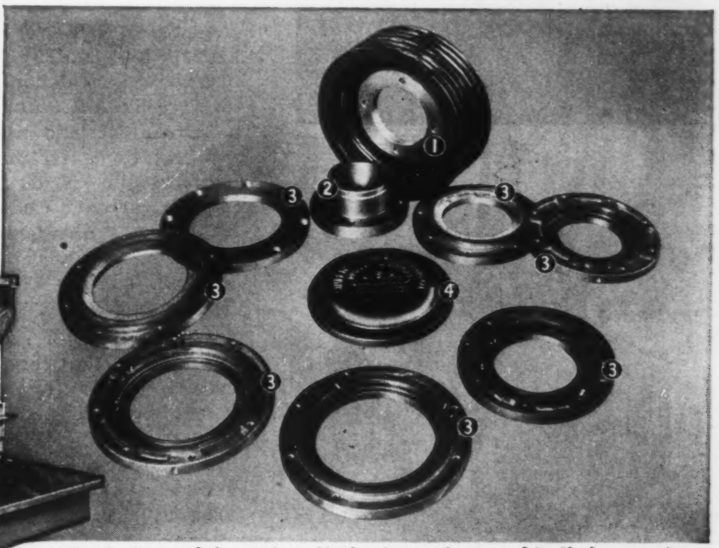


Fig. 1—Some of the various Meehanite castings used in Shakeout units.

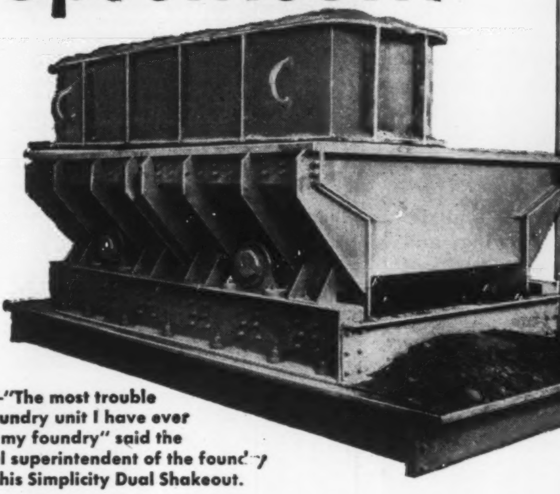


Fig. 2—"The most trouble free foundry unit I have ever had in my foundry" said the general superintendent of the foundry using this Simplicity Dual Shakeout.

MEEHANITE® CASTINGS

As BUILDERS of rugged foundry, coal, mining and materials' handling equipment—equipment which gives truly "trouble free" service under severe conditions, Simplicity Engineering Co., Durand, Michigan, use Meehanite castings (Fig. 1) to construct the operating mechanism of units like the 8′ x 10′ Dual Shakeout (Fig. 2).

The castings include:

1 Machine sheave
2 Shaft adapter for mounting sheaves
3 Grease retaining seals
4 Name and cover plate

Produced with the rigid control provided by the Meehanite manufacturing processes, these castings provide *better* engineering properties—contributing to the equipment strength, resistance to wear, toughness, soundess and uniformity.

Write us for a copy of the Meehanite Handbook or send us your

MEEHANITE FOUNDRIES

American Brake Shoe Co.	Mahwah, New Jersey
The American Laundry Machinery Co.	Rochester, New York
Atlas Foundry Co.	Detroit, Michigan
Banner Iron Works	St. Louis, Missouri
Barnett Foundry & Machine Co.	Irvington, New Jersey
H. W. Butterworth & Sons Co.	Bethayres, Pennsylvania
Continental Gin Co.	Birmingham, Alabama
The Cooper-Bessemer Corp.	Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co.	Portland, Oregon
Farrel-Birmingham Co., Inc.	Ansonia, Connecticut
Florence Pipe Foundry & Machine Co.	Florence, New Jersey
Fulton Foundry & Machine Co., Inc.	Cleveland, Ohio
General Foundry & Manufacturing Co.	Flint, Michigan
Greenlee Foundry Co.	Chicago, Illinois
The Hamilton Foundry & Machine Co.	Hamilton, Ohio
Johnstone Foundries, Inc.	Grove City, Pennsylvania
Kanawha Manufacturing Co.	Charleston, West Virginia
Koehring Co.	Milwaukee, Wisconsin
Lincoln Foundry Corp.	Los Angeles, California
The Henry Perkins Co.	Bridgewater, Massachusetts
Pohlman Foundry Co., Inc.	Buffalo, New York
Rosedale Foundry & Machine Co.	Pittsburgh, Pennsylvania
Ross-Meehan Foundries	Chattanooga, Tennessee
Shenango-Penn Mold Co.	Dover, Ohio
Sonith Industries, Inc.	Indianapolis, Indiana
Standard Foundry Co.	Worcester, Massachusetts
The Stearns-Roger Manufacturing Co.	Denver, Colorado
Traylor Engineering & Mfg. Co.	Allentown, Pennsylvania
U. S. Challenge Co.	Centerville, Iowa and Batavia, Illinois
Valley Iron Works, Inc.	St. Paul, Minnesota
Vulcan Foundry Co.	Oakland, California
Warren Foundry & Pipe Corporation	Phillipsburg, New Jersey
E. Long Ltd.	Orillia, Ontario
Otis-Fensom Elevator Co., Ltd.	Hamilton, Ontario

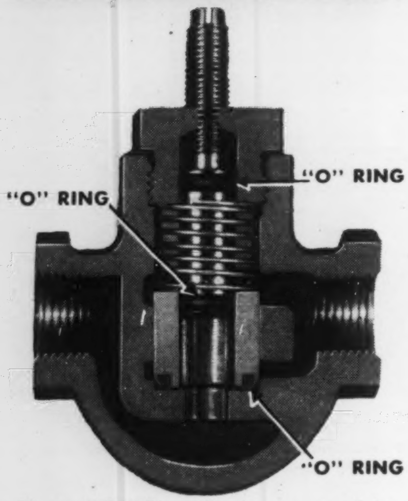
"This advertisement sponsored by foundries listed above."

Meehanite®

PERSHING SQUARE BUILDING • NEW ROCHELLE, N. Y.

USE
"O" RING
SEALS
(The modern packing method)

FOR SIMPLICITY • RELIABILITY
LOW COSTS • SPACE SAVINGS



Three "O" Ring Seals are used in this Automatic Cylinder Speed Control Valve made by AIRMATIC VALVE, INC. of Cleveland, Ohio. This valve, placed in a fluid line between the operating valve and the cylinder, automatically controls the piston stroke at any selected speed.

The lower two "O" Rings in the poppet assembly are rolled into special grooves. The adjustment stem "O" Ring is installed in a standard groove. All are leakproof on air, oil or water to pressures over 1000 P.S.I.

This valve is one of many examples that prove how "O" Ring Seals solve tough problems.

Handbook of "O" RING
PLASTIC and RUBBER

• **Investigate "O" Ring Seals. Consult the "O" Ring specialists. Send for our "O" Ring Handbook. It's free.**

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Products, Inc.
Box 431 • Dayton 1, Ohio

10-hp motor through simple gear train. George Gorton Machine Co., Racine, Wis.

SOLDERING TOOL. Lightweight, operates on resistance heating principle. Clamping work with soldering tool causes part to heat almost immediately. Thumb switch permits close heat control. 450 watt unit has 2 heats, 5.3 and 4.2 volts. Ideal Industries Inc., Sycamore, Ill.

Processing

ELECTRIC FURNACE. For heat treating. Of welded steel construction, with 6-in. insulation, automatic temperature control, and nickel-chromium heating elements, furnace operates on 230-volt, 50/60 cycle, single-phase current. Chamber opening, 8½ by 7½ in.; depth, either 13½ or 18 in. Counterbalanced door operation. Thermo Electric Mfg. Co., Dubuque, Iowa.

ELECTRIC FURNACE. For tool and die work, hardening and drawing, and laboratory ash analysis. Top and bottom heating elements in one set, side elements in other set. Temperatures between 100 and 2000 F accurately held. Current consumption on 8 by 6 by 12-in. capacity model, 4 kw, either 110 or 220-volt, single phase. K. H. Huppert Co., Chicago.

Service Equipment

ELECTRIC WATER HEATER. For installation under continuous kitchen counter tops. Either 30 or 40-gal capacity, without back splasher. Permit installation under any linoleum, plastic, metal, or wood counter 36 in. or more high. General Electric Co., Bridgeport, Conn.

TRACTOR. Four-wheel drive tractor for farm or commercial use. Steering levers control self-energizing brakes on each side of differential, permitting turning radius of 5½ ft. Complete with demountable 6.00 x 16 pneumatic tires, self-starter, battery and lights. Four-cylinder, 16-hp, 61-cubic in. displacement engine consumes 0.8 gal gas per hour at full load. Detroit Tractor Corp., Detroit.

Testing

TESTING MACHINE. In 7 ranges from 250 to 10,000 lb capacity. Portable; weighs 138 lb. Loading accomplished by screw, hand powered or motor driven. Capacity can be changed by replacing removable dynamometer with auxiliary dynamometer with desired range. Suitable for tension, compression, transverse or shear tests on fabrics, cord, rope, wire, wood, steel and other metals. W. C. Dillon & Co., Chicago.

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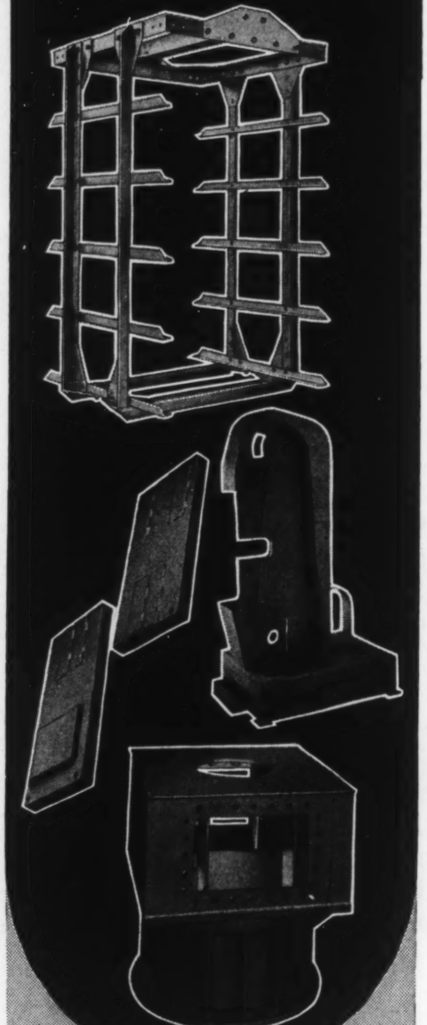
Littleford facilities and skilled workmen are qualified to fabricate any product of plate or sheet metal that may apply to your production.

Littleford weldments have long been known for uniformity, accuracy, strength and adaptability. Rigid demands of manufacturing plants, design engineers, have been met easily and without exception.

If you have a weldment problem send blueprints to Littleford, see how experience can insure economies in plate and sheet metal fabrication.



FABRICATORS OF PLATE AND SHEET METALS

LITTLEFORD

LITTLEFORD BROS., INC.
424 E. Pearl St., Cincinnati 2, Ohio

To generate electricity for transmitting messages, the telegraph industry relied on batteries. Cells of the gravity battery were cumbersome jars — 12 in. high, 8 in. across. By 1893, finding space for thousands of jars threatened the industry's expansion. Crocker-Wheeler, oldest electric motor manufacturer, designed and built motor-generator sets. Each, occupying a space two ft. square, did the work of 500 of the old cells which took up more than 222 sq. ft.

1893
1 2 3 4 5 6
7 8 9 10 11 12 13
14 15 16 17 18 19 20
21 22 23 2

When the Telegraph Industry escaped from GLASS JARS…

CROCKER-WHEELER

made motor news

Today, 55 years and over a million motors later, Crocker-Wheeler no longer concentrates on the design and manufacture of special motors exclusively. But the pioneering spirit and engineering skill of Crocker-Wheeler that persuaded industry to adopt electricity half a century ago are still very much alive—in the performance of C-W standard motors today.

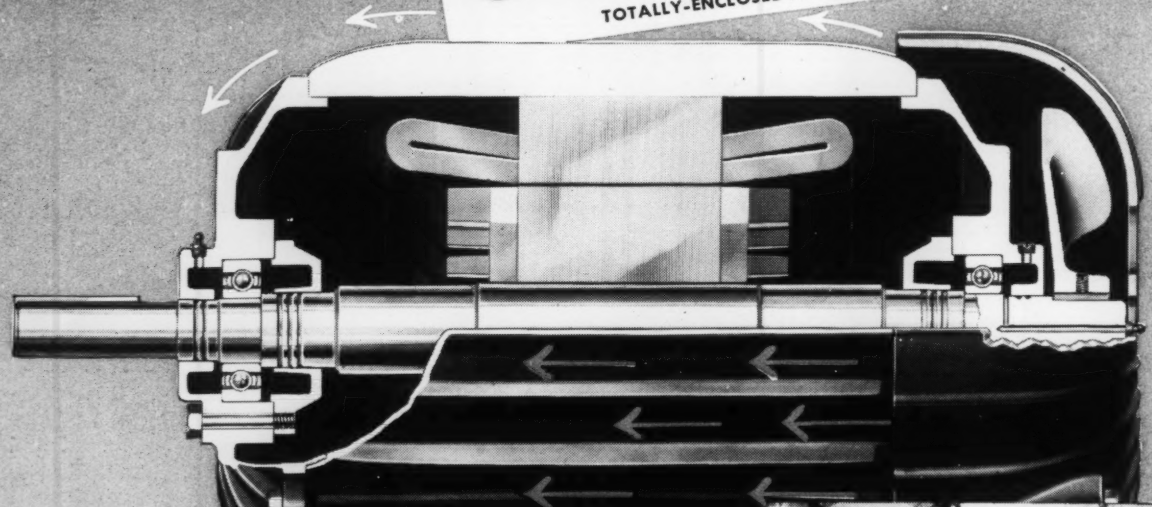
Past and present (yes, and the future) are inseparably fused at Crocker-Wheeler. A high percentage of the skilled workers who helped C-W make motor news through the years are still on the job, bringing to motor problems of modern industry a rare background of knowledge and engineering experience.

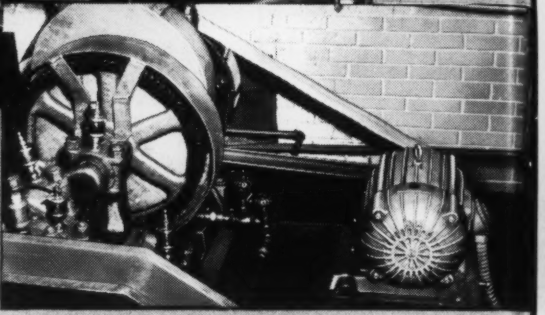
You'll understand what we mean (if you don't already know) as new, more efficient standard motors, developed by Crocker-Wheeler, are introduced in 1949. You can sense it just by *talking* to Crocker-Wheeler when you have a difficult motor problem. Here, you will say, is a master of the art of motor-making—but more than that, the kind of organization with which you would like to do business. Crocker-Wheeler Electric Manufacturing Company, Ampere 3, N. J.

AND CROCKER-WHEELER IS MAKING MOTOR NEWS TODAY ➡

CROCKER-WHEELER *Sealedpower* MOTOR

TOTALLY-ENCLOSED . . . FAN-COOLED





Sealedpower Motor driving a vertical triplex power pump where moisture is excessive.

Saves 80% of Maintenance Costs

You can make maintenance savings of 80% and *more* with Crocker-Wheeler Sealedpower Motors. The secret? C-W dollar-saving design. No other totally-enclosed, fan-cooled motor has *exterior* cooling, with the fan-driven airstream blowing over a finned frame, carrying dust and fumes *outside* and *away*. (The outside fins that identify a Sealedpower Motor provide over 150% more cooling surface.)

But that's not all — this motor keeps cooler longer because it keeps cleaner. There's no place for lint or dirt to *collect . . .* nothing to hold heat *in*. Even on the really dirty jobs, a Sealedpower Motor will keep production going many times longer than "ventilating passage" motors, without a shutdown for cleaning.

For years of cool, clean operation and low maintenance cost, specify Sealedpower Motors. They're stock motors made for the toughest service. In new ratings from 3 to 60 hp.

CROCKER-WHEELER
SEALEDPOWER MOTOR

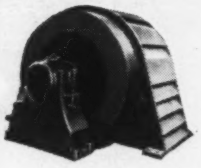
Crocker-Wheeler Electric Manufacturing Company, Ampere 3, N. J. Division of The Joshua Hendy Corp., Branch Offices: Boston, Buffalo, Chicago, Cincinnati, Cleveland, Los Angeles, Milwaukee, New York, Philadelphia, Pittsburgh, San Francisco, Washington, D. C. Representatives in principal cities.

SEND FOR BOOKLET, "It's Different — it's a Dollar-Saver." Tells why the Sealedpower Motor will save money for you.

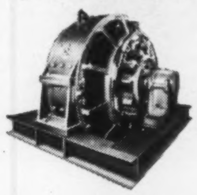
WHATEVER YOUR MOTOR REQUIREMENTS — CALL ON CROCKER-WHEELER

If Crocker-Wheeler builds it, it's a better built machine.

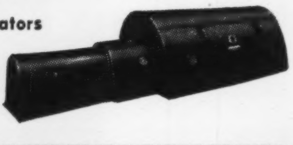
Horizontal and Vertical Protected-Type Induction Motors



A-C Generators and High Speed Synchronous Motors



Large D-C Motors and Generators



Turbogenerators

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ELECTRIC MANUFACTURING COMPANY, AMPERE 3, N. J.

Division of Joshua Hendy Corporation

All the
STAINLESS STEEL
you want
...every way you want it!
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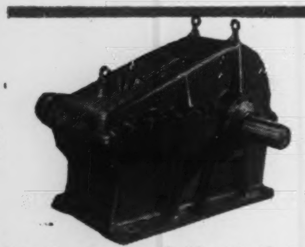
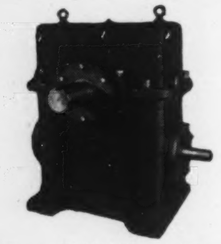
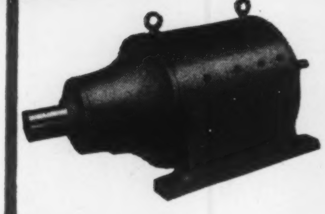
ESTABLISHED 1888



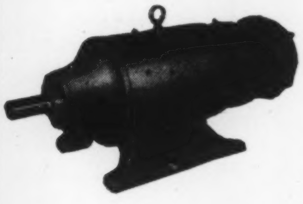
Continuous-tooth Herringbone
Single, Double, Triple Reduction



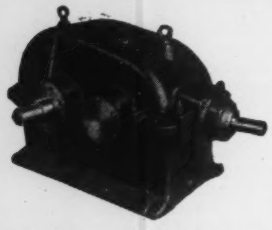
Type "H" Worm Gear



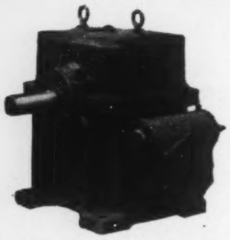
Straight Line Gear Reducer



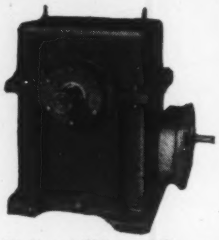
Motorized Reducers



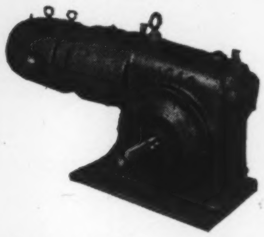
Spiral Bevel Herringbone



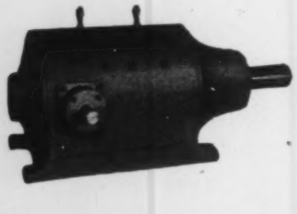
Double Worm Gear



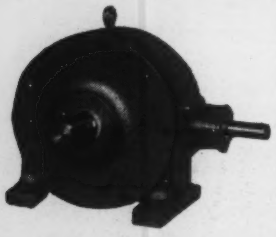
Helical Worm Gear



Motorized Worm Gear



Right Angle Gear Reducer



Spiral Bevel Gear

D.O.James Gear Manufacturing Co. is constantly developing and continuing to improve its variety of gear speed reducers—enabling engineers and designers of power-saving equipment to meet and cope with space limitations, horsepower requirements, ratios, location of driven or driving shafts and the type of drive that the many and varied installations require. Catalogs are available containing complete informative engineering data that will assist in the selection of the type of reducer for the specific job to be done.

D.O.JAMES GEAR MANUFACTURING CO.
Since 1888—Makers of Cut Gears, Gear Reducers and Flexible Couplings
1140 W. MONROE STREET • CHICAGO, U. S. A.

FOR SOMETHING EXTRA

MORSE

silent chain

COUPLINGS

IF YOU'RE looking for something extra in chain coupling performance, look no further.

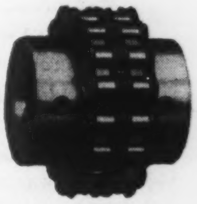
The Morse Silent Chain Coupling gives you that "extra something" in durability, ruggedness, and long, trouble-free service life. The Morse Silent Chain Coupling is one of the biggest sellers in the flexible coupling field—and small wonder when you see its advantages.

With a torque capacity normally greater than that of the shafts on which it is mounted, the Morse Silent Chain Coupling secures its flexibility through design. Load distribution through the many chain links and pins to the wide surfaces of the sprocket teeth assures small unit stresses.

The Morse Silent Chain Coupling is easy to install and disconnect. The chain may be removed without disturbing the sprocket halves, or either sprocket may be removed endwise without disconnecting the chain. Protective casings (interchangeable between Silent Chain and Roller Chain Couplings), either stamped steel or plastic, are available for use in continuous, high-speed operations. They are easily installed and provide sealed-in lubrication plus maximum protection from dirt, grit and water chemicals. All standard bore sizes can be met from regular stock.

New! Informative catalog on Morse Silent Chain and Roller Chain Couplings—complete engineering and application data. Write for catalog C45-48. Morse Chain Company, Dept. 301, Detroit 8, Michigan.

• • •



Morse Roller Chain Couplings . . . Consisting of two steel sprockets with hardened teeth, wrapped with a strand of Morse Standard double-width roller chain, the Morse Roller Chain Coupling is another big seller in the Morse line. Rugged and economical, it provides flexibility and large capacity in applications of moderate speeds and steady loads.

Morflex Couplings

Roller Chain Drives

Morse-Rockford Clutches

MORSE

MECHANICAL
POWER TRANSMISSION
PRODUCTS

A PRODUCT OF
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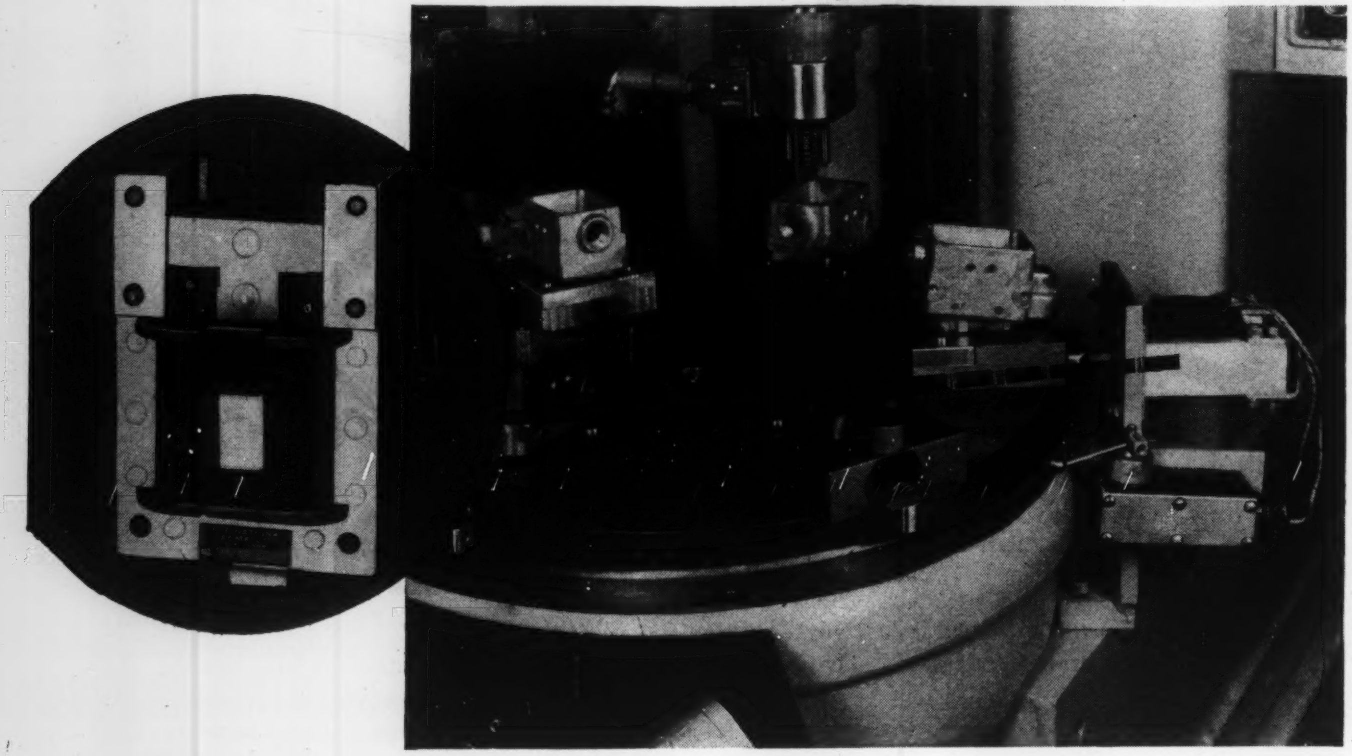
Morflex Radial Couplings

PRODUCTION UPPED MORE THAN 4 TO 1

with NAMCO "Stellite"-Welded SOLENOIDS



● Here's a typical example of how you can save time and money by a push in the right place with Namco Solenoids.

Where you want unfailing automatic action—precise, positive and synchronized in a production cycle, Namco Solenoids are the answer.

In the application illustrated, for example, work-ejection is speeded by a Solenoid. Here latch pins are being riveted in switch boxes on a Denison Hydraulic Multipress.

When the operator pried the boxes off by hand, the best production was 60 per hour. With the introduction of a 14-lb., push-type Namco Solenoid, energized by a standard Namco Super-Sensitive Switch, to actuate the work-releasing plunger in the holding fixture, the end result was an increase to 250 boxes per hour! It's easier work—and higher pay—for the operator.

The implication is obvious: Wherever an automatic push or pull will do the job—be it ejecting work; actuating valves, levers, switches, knives or machines; sorting, holding or imprinting parts—it's a job for Namco Solenoids. They're simple; they're compact. We *engineer them to your specific application*, not just ship them off the shelf. On your next job, may we recommend the size and style best suited to your requirements?

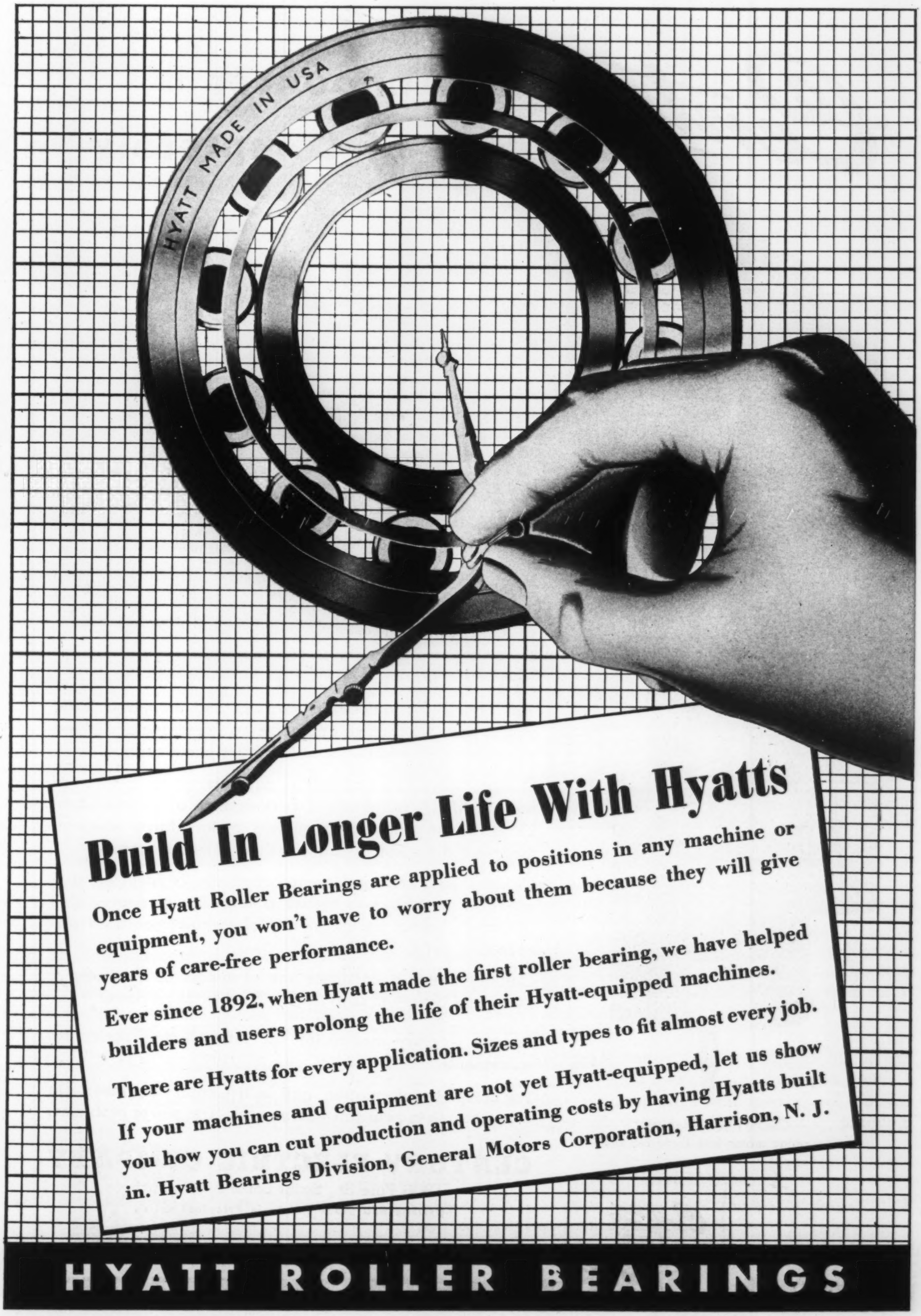
NAMCO
"STELLITE"-WELDED
THE NATIONAL ACME COMPANY

Namco "Stellite"-Welded Solenoids are built in a variety of sizes and mountings, both push and pull types, to meet every commercial application. The complete standard range is illustrated and tabulated in Engineering Bulletin EM-46. Ask for your copy.

The NATIONAL ACME CO.

180 EAST 131st STREET · CLEVELAND 8, OHIO

Acme-Gridley Bar and Chucking Automatics: 1-4-6 and 8 Spindle · Hydraulic Thread Rolling Machines · Automatic Threading Dies and Taps · The Chronolog · Limit, Motor Starter and Control Station Switches · Solenoids Centrifuges · Contract Manufacturing



Build In Longer Life With Hyatts

Once Hyatt Roller Bearings are applied to positions in any machine or equipment, you won't have to worry about them because they will give years of care-free performance.

Ever since 1892, when Hyatt made the first roller bearing, we have helped builders and users prolong the life of their Hyatt-equipped machines.

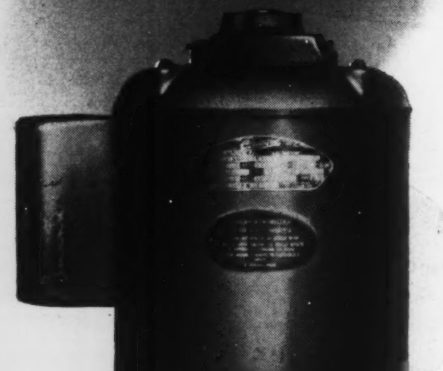
There are Hyatts for every application. Sizes and types to fit almost every job.

If your machines and equipment are not yet Hyatt-equipped, let us show you how you can cut production and operating costs by having Hyatts built in. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.

HYATT ROLLER BEARINGS

Century Announces a Line of Completely NEW Jet Pump Motors

Century ½ horsepower
jet pump motor with keyed shaft



Century ½ horsepower
jet pump motor with threaded shaft

Designed for automatic starting and stopping, these motors have the starting and accelerating torque and speed characteristics especially suited to jet pump service.

The new capacitor start single phase jet pump motors are built to NEMA standards of performance and dimensions. Three phase and direct current motors have identical mounting dimensions—making them interchangeable.

Century Jet Pump motors are ruggedly constructed and carefully balanced to assure a long life of dependable operation, under the frequently abnormal conditions surrounding pump installations.

Century builds a complete line of motors in a variety of kinds and types—in sizes from 1/6 to 400 horsepower.

Specify Century motors for all your electric power requirements.

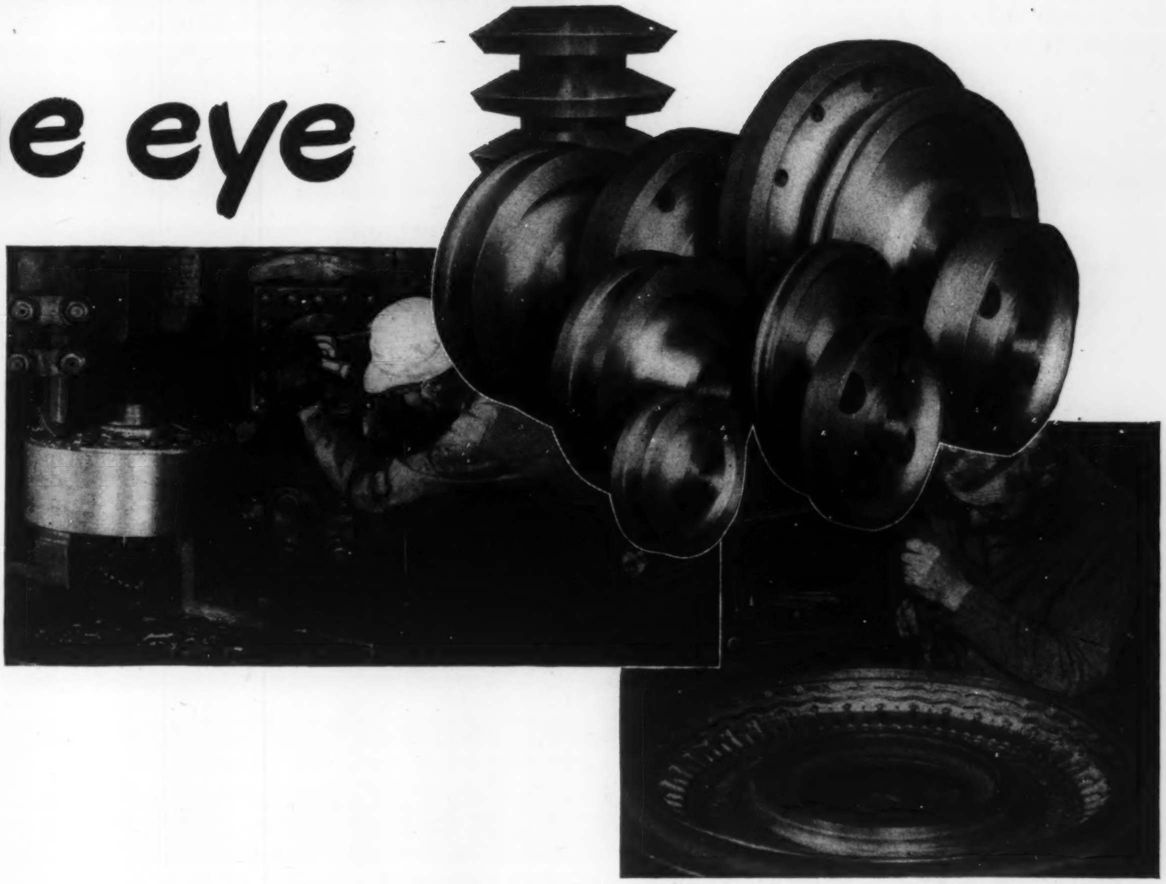
For complete information, call in a Century engineer. He may be able to help you with your electric power problems.

CENTURY ELECTRIC COMPANY
1806 Pine St., Saint Louis 3, Missouri
Offices and Stock Points in Principal Cities

Century C MOTORS

616

More than meets the eye



Almost everybody comments on the neat, trim appearance of Bethlehem's circular forgings. They're given a rough-machining before they're shipped, and a beautiful job it is. For you, it has a practical value, too—saves a step in your plant.

But the real worth of these circular steel blanks is down inside. There's more than meets the eye. You can't see it—but down below that neat, machined surface there's homogeneity . . . strength . . . toughness . . . good grain structure . . . uniform density. These are the qualities you want in gear blanks—and blanks for crane wheels, sheave wheels, turbine rotors, tire molds, flywheels, and similar round parts. These are the qualities that give you a sturdy, shock-resisting finished product.

We feel that our unique manufacturing process has much to do with it. The blanks are formed in a mill that combines the operations of upsetting, forging, and rolling—a mill that smoothly transforms hot steel blocks into circular blanks of predetermined thicknesses and contours.

Booklet 216 tells you much about this process, and also shows many, many ways in which the blanks can be used. Write for a free copy . . . or, if you prefer, a Bethlehem representative will gladly call on you and furnish all details of these circular products.

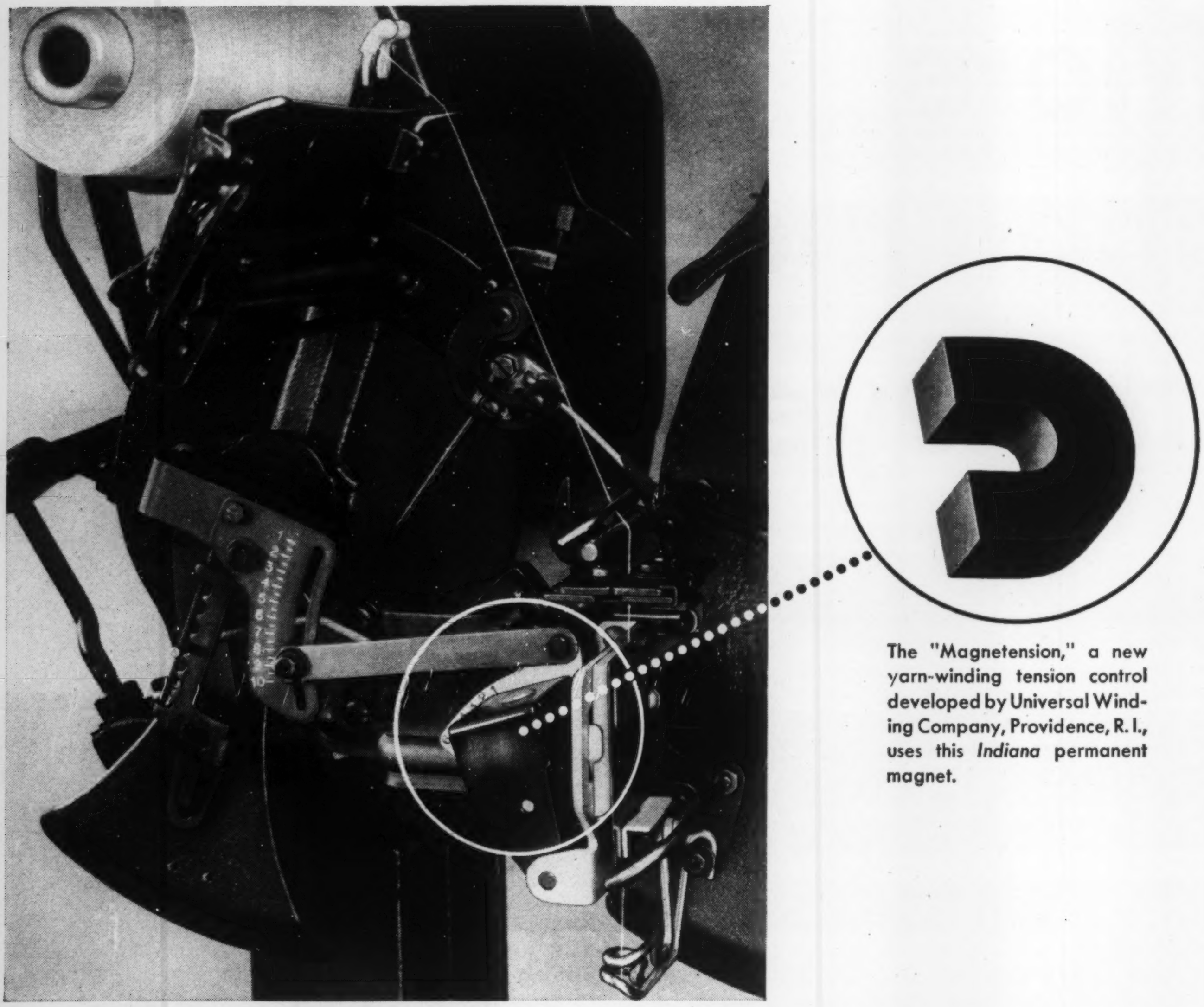
★ BETHLEHEM STEEL ★

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation ★

Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM ROLLED-AND-FORGED CIRCULAR PRODUCTS



The "Magnetension," a new yarn-winding tension control developed by Universal Winding Company, Providence, R. I., uses this *Indiana* permanent magnet.

INDIANA PERMANENT MAGNETS TAKE THE "KINKS" OUT OF YARN-WINDING

● Here's another job made simple by *Indiana* permanent magnets—they hold tension leaves against wear plates to provide even winding tension on yarn-winding machines. And here are the direct benefits: non-multiplying tension; fewer broken filaments; less end breakage, cut ends, or loops at cones; less attention to machines; *and a better product at less cost.*

"PACKAGED ENERGY" MAY BE *YOUR* ANSWER, TOO . . .

Indiana permanent magnets provide constant, *predetermined* force for *many* needs. In magnetic chucks and separators for holding and lifting . . . in snap switches and pressure devices for replacing springs . . . in magnetic drives for transferring motion through seals without mechanical connections . . . the list is practically endless.

HOW AND WHERE TO USE PERMANENT MAGNETS . . .

Write for free Book No. 4H-3—the new reference manual by *Indiana.* It shows how permanent magnets save space, weight, and money; lists applications; gives materials and design data. If *you* have an application problem, let's get our engineers together. The experience of forty years and more than 30,000 successful designs is at your call. Write *today.*

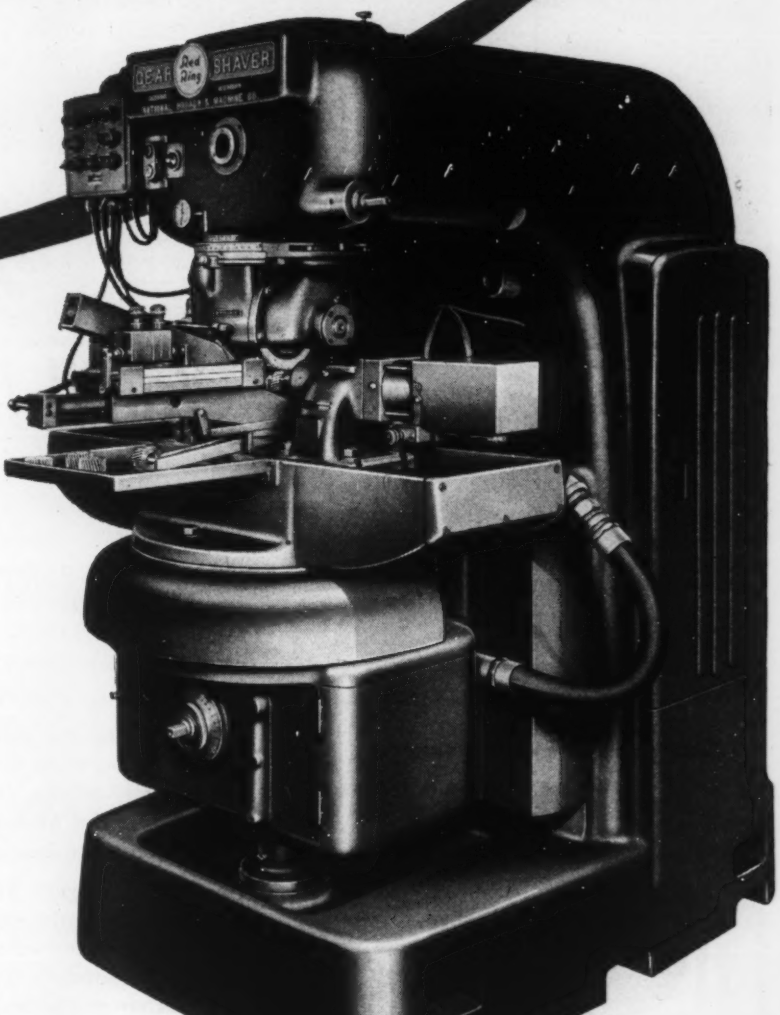
INDIANA
PERMANENT
MAGNETS

THE INDIANA STEEL PRODUCTS COMPANY

6 NORTH MICHIGAN AVENUE • CHICAGO 2, ILLINOIS

SPECIALISTS IN "PACKAGED ENERGY" SINCE 1908

AUTOMATIC LOADING permits you to turn out Precision Gears with unskilled operators at MAXIMUM PRODUCTION RATES



You as a gear manufacturer under present industrial and market conditions can correctly evaluate production equipment that:

❶ Assures extremely close gear tolerances consistently.

❷ Does not require any mechanical skill to operate.

❸ Eliminates operator fatigue and its effect on morale.

❹ Operates continuously at mass production speed.

That is precisely what you can have with Red Ring Automatic Loading in connection with Gear Shaving Machines GCU or GCV.

Either of these machines so equipped can be run continuously merely by keeping a supply of work gears in the magazine and removing the finished gears. One operator easily serves a battery of machines, for the entire machining operation is entirely automatic.

Production rates are phenomenal. Write for descriptive literature.

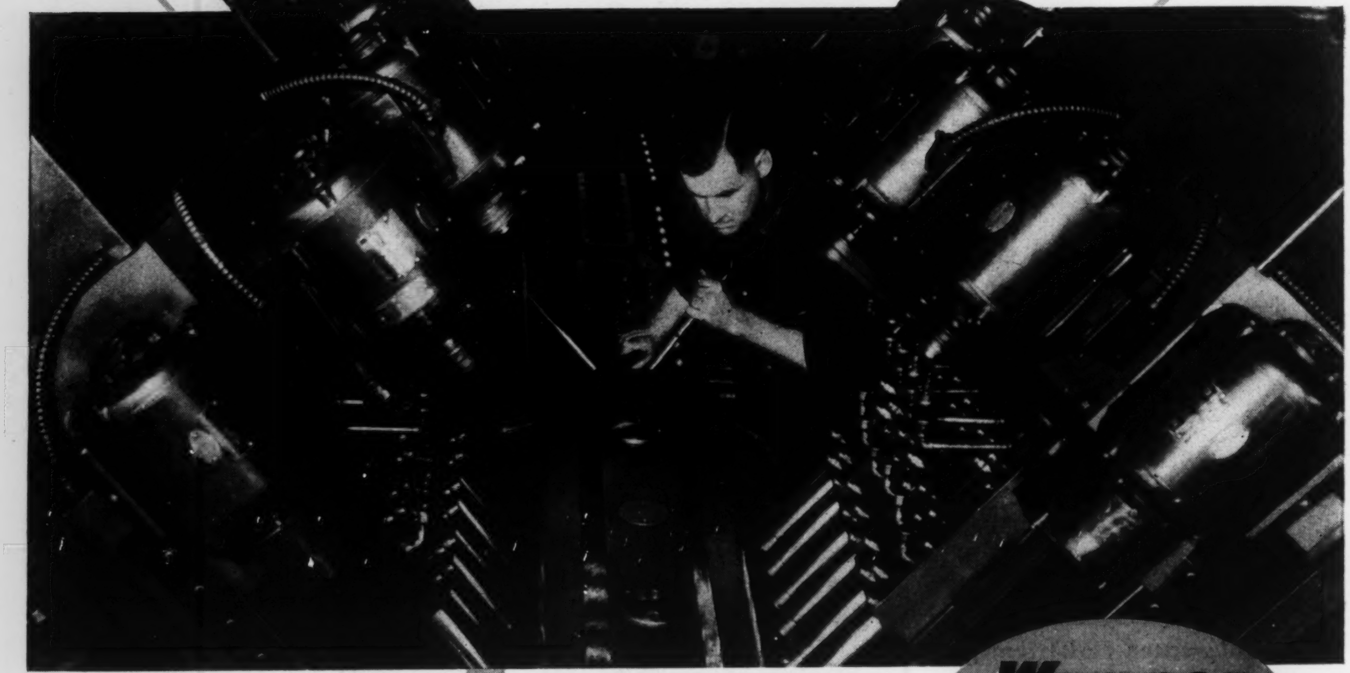
SPUR AND HELICAL
GEAR SPECIALISTS
ORIGINATORS OF ROTARY SHAVING
AND ELLIPTOID TOOTH FORM

NATIONAL BROACH AND MACHINE CO.

5600 ST. JEAN • • • • • • • • • DETROIT 13, MICHIGAN

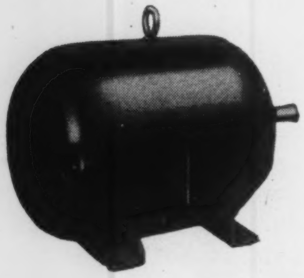
WORLD'S LARGEST PRODUCER OF GEAR SHAVING EQUIPMENT

Where PRECISION Counts...



You'll find Wagner Motors on the job...

Totally-enclosed Non-ventilated Motor



Totally-enclosed Fan-cooled Motor

Real precision in a machine tool requires motors that operate smoothly, quietly and with minimum vibration. Wagner Motors are noted for these qualities and for long-lived dependability and economical operation as well!

That's why Wagner Motors have been used extensively and are recommended by many widely-known machine tool manufacturers. If you want your machine tools and equipment to operate with precision, and with a minimum of costly "down-time"—choose Wagner Motors, too. Bulletin MU-185 gives information on the complete line of Wagner Motors. Write for a copy.

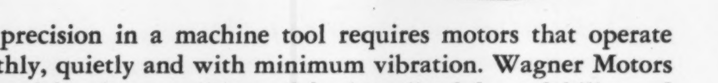
Buyers of Wagner Motors get Nationwide Service! More than 450 Wagner Authorized Electrical Service Stations and Parts Distributors augmented by 25 Wagner-owned Service Branches are ready to immediately supply on-the-spot service, factory guaranteed exchange motors, or genuine Wagner parts. Write for Bulletin MU-24 for complete list.

Wagner Electric Corporation

6404 PLYMOUTH AVE., ST. LOUIS 14, MO., U. S. A.

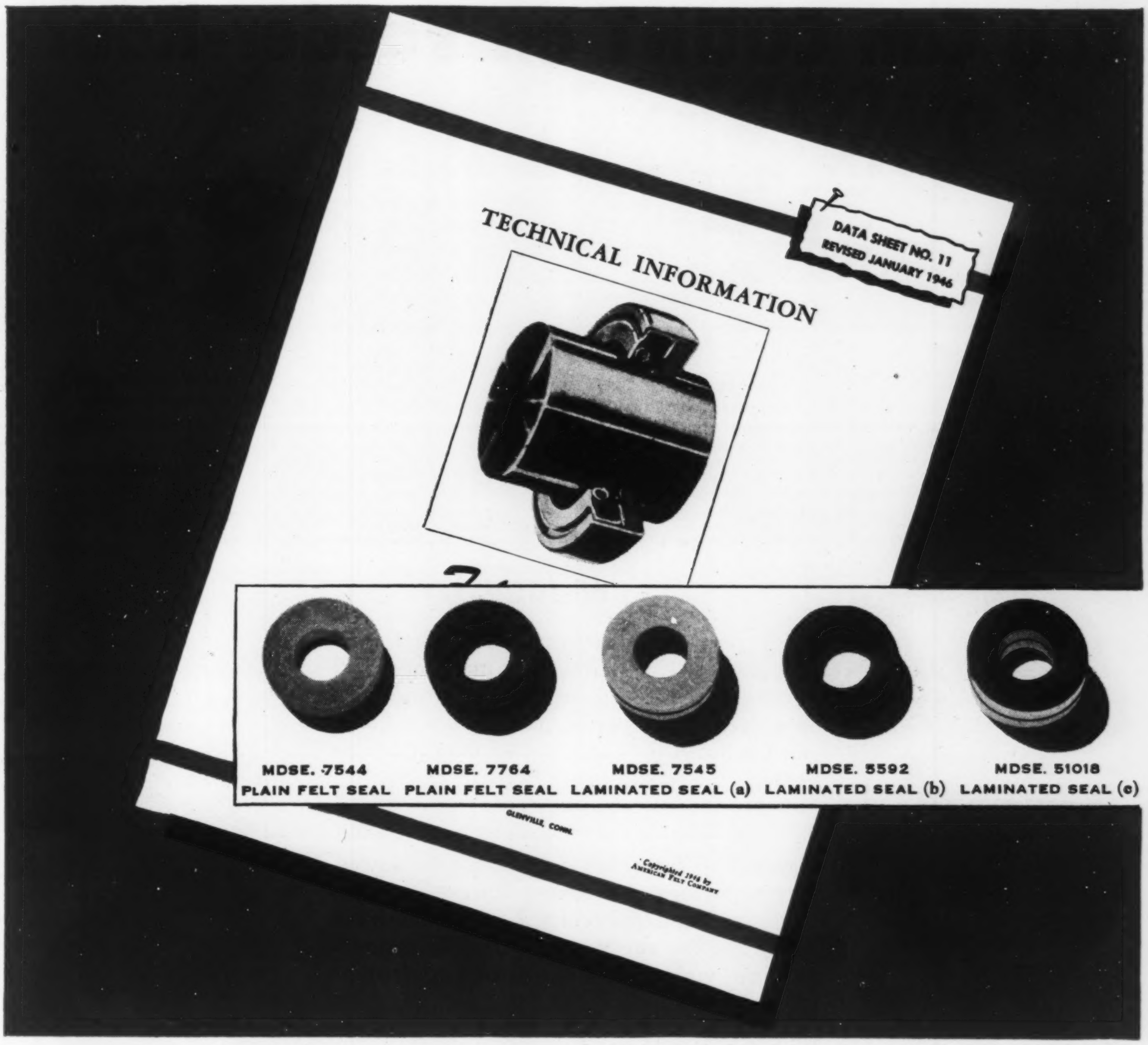
Consult Wagner Engineers on all Electric Motor Problems

Wagner Electric Corporation EST. 1891



• ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE PRODUCTS •

M49-5



TECHNICAL INFORMATION

DATA SHEET NO. 11
REVISED JANUARY 1946

GLENVILLE, CONN.

Copyrighted 1946 by
American Felt Company

Felt Seals can work 3 ways for you

● Here are the three mechanical sealing functions performed by felt seals: (1) *they store* lubricants within themselves and hence lubricate bearings and shafts; (2) *they retain* lubricants, including pressurized, within housings, and (3) *they exclude* dust, dirt, water and other substances, giving effective protection against equipment failures due to leakage or impurities. There are many types of felt seals, both plain and laminated, to meet a wide range of conditions. For illustrative samples and complete technical information, write for Data Sheet No. 11, "Felt Seals, Their Design and Application"—an authoritative reference on this important subject. And when ordering felt for seals or other uses, be sure it is American Felt.

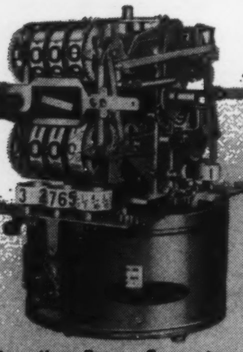
American Felt Company

TRADE MARK

GENERAL OFFICES: GLENVILLE, CONN.

Engineering and Research Laboratories: Glenville, Conn. PLANTS: Glenville, Conn.; Franklin, Mass.; Newburgh, N. Y.; Detroit, Mich.; Westerly, R. I. SALES OFFICES: New York, Boston, Chicago, Detroit, Cleveland, Rochester, Philadelphia, St. Louis, Atlanta, Dallas, San Francisco, Los Angeles, Portland, Seattle, Montreal.

You Can COUNT on Veeder-Root

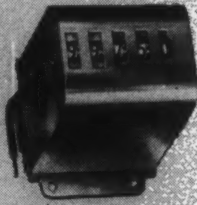


Gasoline Pump Computer ("Head for Figures") computes exact price of gasoline pumped into your tank.

New 1260 General-Purpose Counter, compact, streamlined, easy to build into any product.

... at any point
... in any business or industry

New 1248 Reset Magnetic Counter for remote indication of machine production, from plant to office.



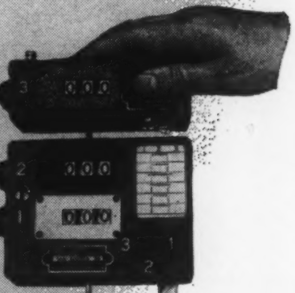
New 1268 Non-Reset Magnetic Counter for coin machines.

Typewriters, tractors, and textile looms ... steel rolling mills, coin machines, and gasoline computer pumps . . . these and hundreds of other machines feature *built-in* Veeder-Root Counters which give their users up-to-the-minute *Facts in Figures* on operation, service, or production.

And these same *Facts in Figures* . . . delivered in terms of turns, strokes, pieces, trips, hours, volumes, lengths, light-flashes, hand-movements, or what have *you?* . . . are the bedrock basis of money-saving, vigilant Veeder-Root *Count*rol.

See that all new machines and equipment you buy are equipped to give you Veeder-Root *Count*rol. And see how *your own products* can build up sales by building-in a Veeder-Root Counting Device. Write.

Revolution-Hour Meter for tractors shows elapsed length of service and when overhaul time is coming due.



2-3 Pick Counter, for textile looms counts picks (shuttle-flights). Counter is convertible from 2 to 3 shifts.

Cut Meter for textile looms permits production of uniform lengths of cloth without "cut marks." Cut Meter knocks-off loom when predetermined length has been woven.

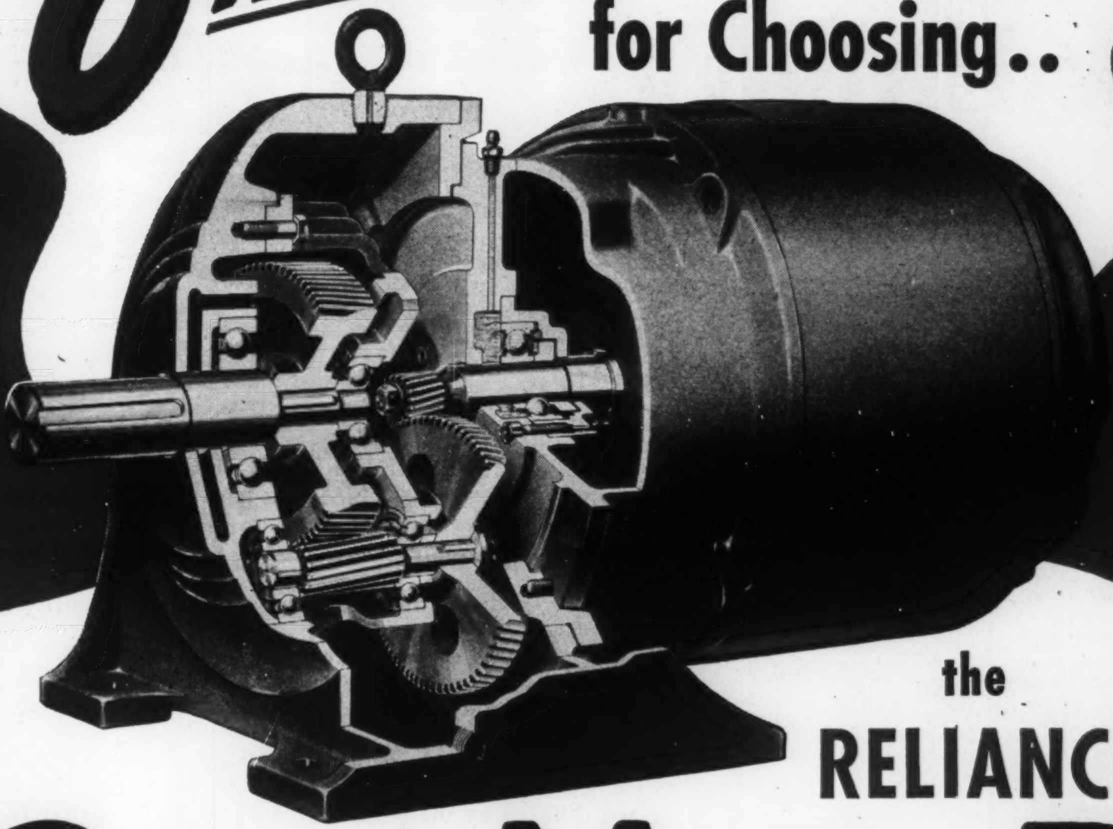
Direct-Reading Counter indicates thickness of steel sheets passing through rolling mill.

Veeder-Root
COUNTERS

VEEDER-ROOT INC. **Hartford 2, Conn.**

In Canada: Veeder-Root of Canada, Ltd., 955 St. James Street, Montreal 3
In Great Britain: Veeder-Root Ltd., Kilspindie Rd., Dundee, Scotland

6 INSIDE REASONS for Choosing..



the RELIANCE GEARMOTOR

1 Helical, wear-hardened gears cut from alloy steel forgings and shaved before hardening for correct eccentricity and helical angle and bright, smooth surfaces—factors contributing to quiet operation and longer life.

2 Gear arrangement in simple train minimizes number of moving parts—promotes quietness.

3 Pinion and gear supported and spaced to reduce deflection—permits high load-carrying capacity.

4 Splash system with large oil reservoir assures constant and thorough lubrication of all parts.

5 Anti-friction bearing construction throughout.

6 Reliance *Precision-Built* Motors provide the maximum in dependable and economical power. Types that may be had with GearMotoR are described in GearMotoR Bulletin C-404. Ask also for bulletins describing Reliance *Precision-Built* A-c. Motors—engineered for every power requirement.

Sales Representatives in Principal Cities

RELIANCE ELECTRIC AND ENGINEERING CO.

1079 IVANHOE ROAD • CLEVELAND 10, OHIO

"Motor-Drive is More Than Power"

notch sensitivity—

cause and cure

Notch sensitivity is the tendency of a material to fatigue failure caused by surface discontinuities — toolmarks, sharp corners, etc. — points of high stress concentration.

Gray Iron has very high resistance to notch sensitivity. Repeated stresses, instead of causing a fracture from a notch, are diffused by the graphite in Gray Iron so that failure of the part is avoided.

Crankshafts, like the one above, illustrate this and other qualities of Gray Iron such as rigidity, vibration absorption and superior bearing characteristics.

For thousands of products, Gray Iron provides a winning combination of useful properties not found in any other material . . . plus ultimate economy.

Write for free booklet, "GRAY IRON—Its Mechanical and Engineering Characteristics, and Details for Designing Cast Components".

Gray Iron Characteristics Include:

- **Castability**
- **Rigidity**
- **LOW NOTCH SENSITIVITY**
- **Wear Resistance**
- **Heat Resistance**
- **Corrosion Resistance**
- **Machinability**
- **Vibration Absorption**
- **Durability**
- **Wide Strength Range**

Make It Better With Gray Iron

GRAY IRON FOUNDERS' SOCIETY, INC.
NATIONAL CITY BANK BLDG., CLEVELAND 14, OHIO

Twin Disc Model CL Clutch

Twin Disc Model EH Clutch

Twin Disc Power Take-off

Simplify your design problems . . .

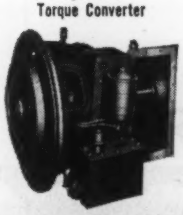
● Specify Twin Disc and you will simplify the problem of fitting power transmission units into the crowded space allotted on most of your equipment.

Twin Disc Heavy-duty Clutches and Power Take-offs are designed compactly . . . are fully enclosed to assure protection against dust and dirt. Overall dimensions are held to a minimum to conserve space and the enclosed feature permits operation in the open without the danger of projecting parts catching while rotating.

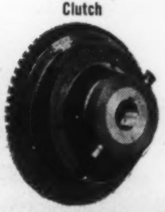
Twin Disc Models CL and EH Clutches are heavy-duty units that meet the need for enclosed-type clutches ranging in sizes from 5.5″ up to 42″ and requiring capacities from 1.5 up to 350 hp per 100 rpm.

Twin Disc Power Take-offs, with single and double-plate clutches, vary in sizes from 6.5″ up to 24″, and are available with capacities up to 650 hp. Recommendations, blueprints and engineering data will be supplied upon request by the TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).

Hydraulic Torque Converter



Heavy Duty Clutch



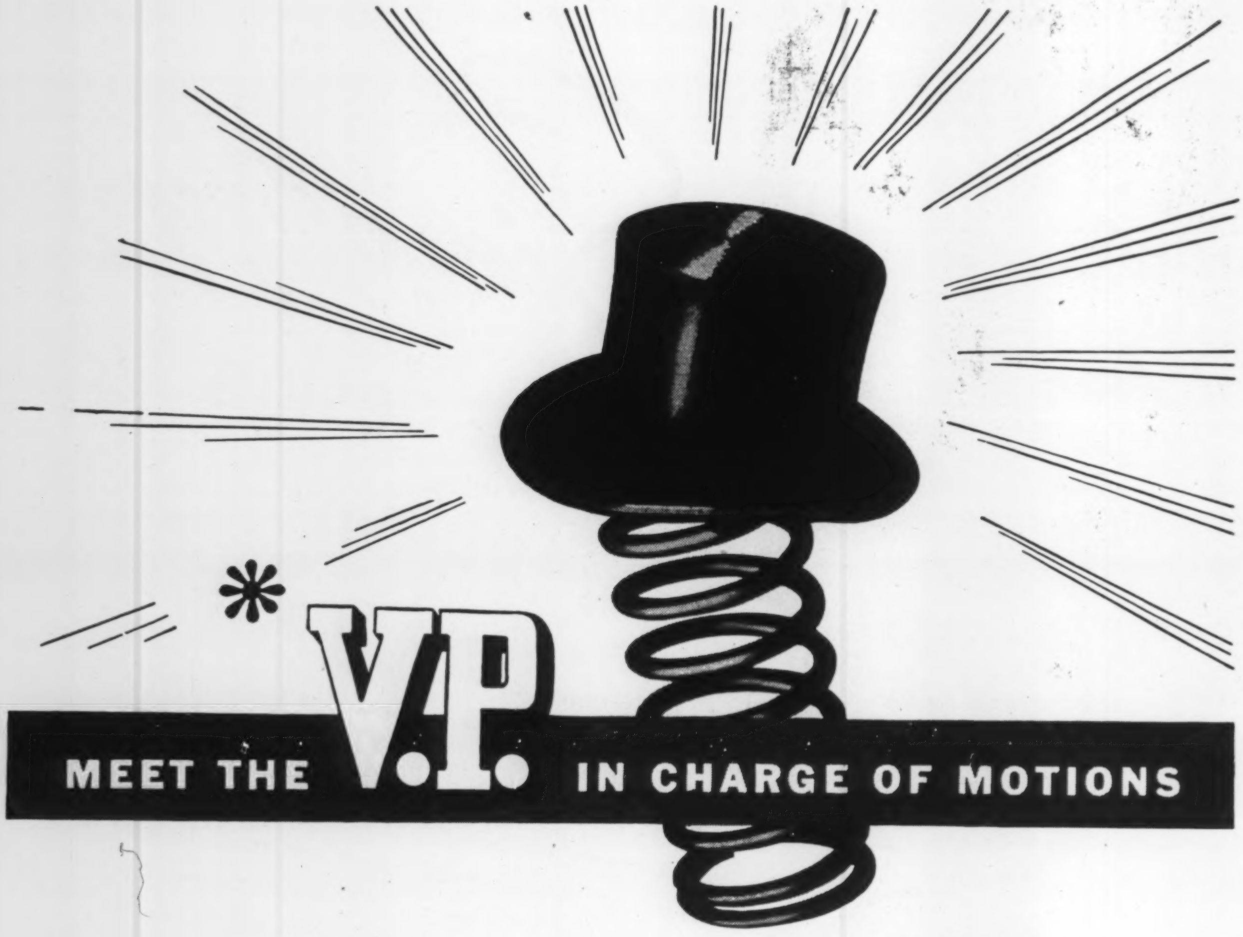
Machine Tool Clutch

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES
REG. U.S. PAT. OFF.

Tractor Clutch

Marine Gear

SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918



*V.P.

MEET THE V.P. IN CHARGE OF MOTIONS

*Vital Part in Mechanical Assemblies

Top job in any mechanism is that which requires a spring—to make it go—to keep it running.

That's why Wallace Barnes constantly improves for your benefit—in its own steel mill where research expands the usefulness and endurance properties of metal—in all its specialty production departments where new methods of coiling and forming springs are developed and perfected.

Your springs may be a simple production job—or a complex design problem. Wallace Barnes does both, capably.

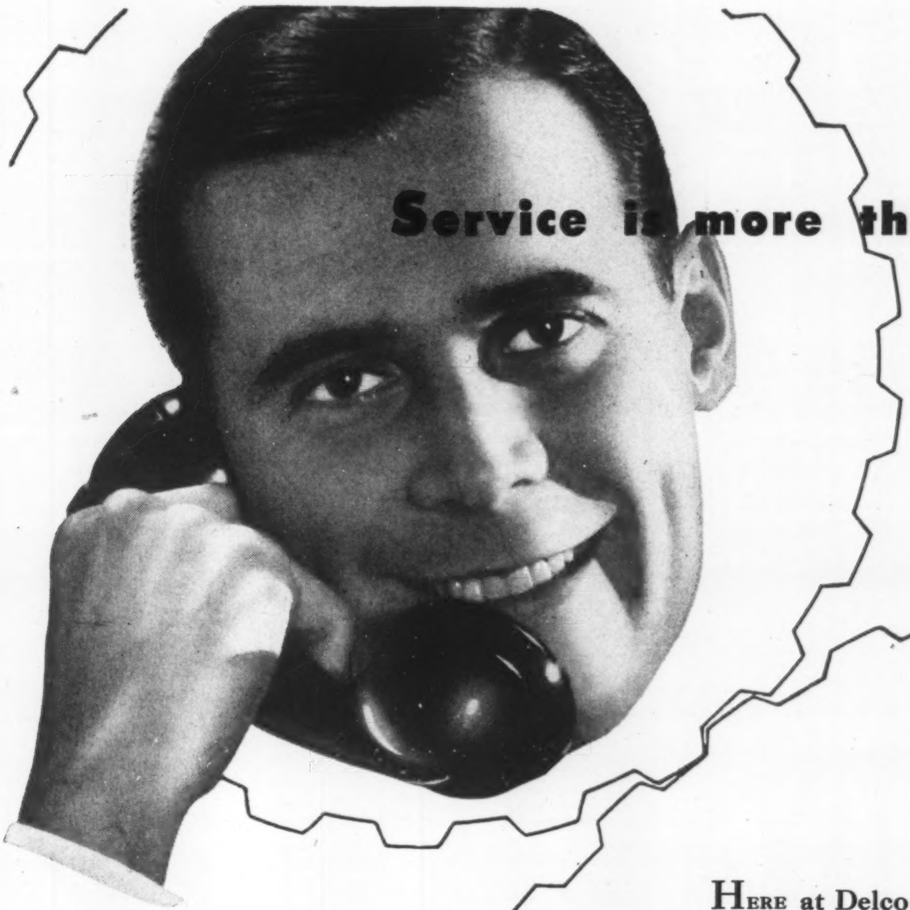
Let's meet your "V.P." soon.

Wallace Barnes SPRINGS

SMALL STAMPINGS • WIRE FORMS • HAIRSPRINGS • COLD ROLLED SPRING STEEL

WALLACE BARNES COMPANY
BRISTOL, CONN.

DIVISION OF THE ASSOCIATED SPRING CORP.
AND IN CANADA, THE WALLACE BARNES CO., LTD., HAMILTON, ONTARIO



Service is more than machinery

Here at Delco Products we recognize the importance of modern machinery. The completeness of our up-to-date mechanical facilities attests to that. Physically, we're more than equal to the swift production pace manufacturers are setting today.

But Delco Products also believes there is an ingredient far more integral to service than even the finest machines. It's a human element—the faculty of regarding each customer as an individual. It's an awareness of his particular requirements, and the disposition of all our resources to help meet them.

That's why Delco Products is organized primarily to accommodate our customers. That's why our scheduling procedures are flexible enough to handle last-minute changes in design or quantity.

And that's why appliance manufacturers who require quality motors produced in quantity trust Delco to deliver.

DELCO MOTORS

DELCO
DAYTON OHIO

DELCO PRODUCTS DIVISION, GENERAL MOTORS CORPORATION, DAYTON, O.

Sales Offices: CHICAGO • CINCINNATI • CLEVELAND • DETROIT • HARTFORD, CONN.

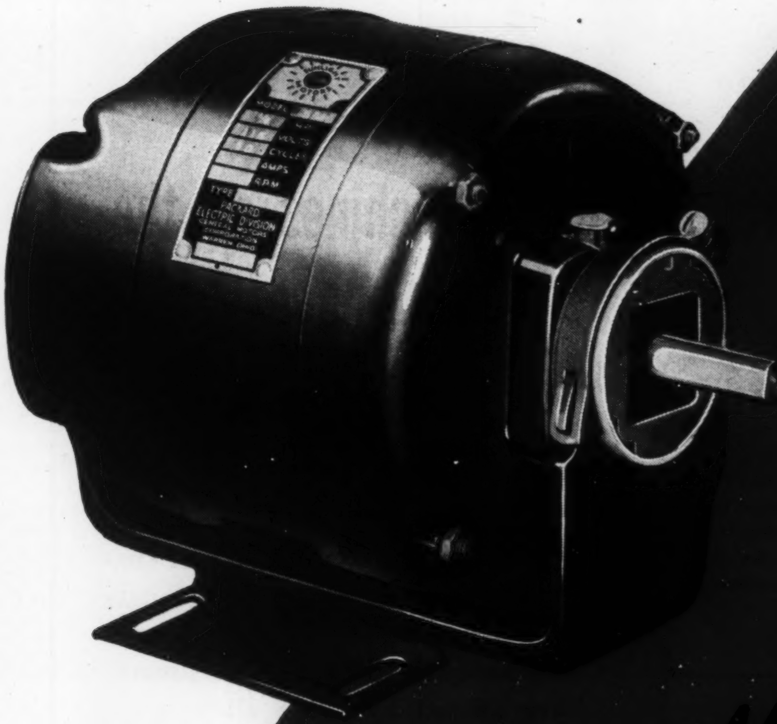
when it's gotta fit...
ON-TIME SCHEDULING
ACCURACY
BRANDT
BALTIMORE
measures up!
BRANDT
• metal stampings
• heavy weldments
• pressed steel shapes
STRATEGICALLY LOCATED
In the midst of major rail, water and highway transportation facilities.

DON'T READ THIS—

unless you need help in meeting production schedules

If you are having difficulty because of material shortage or lack of complete manufacturing facilities Brandt facilities may be the answer to your need. Here, at Brandt we do a complete job from raw materials through manufacturing, cleaning, bonderizing, painting, crating, and shipping. Precision mass production of heavy metal stampings, heavy weldments and pressed steel shapes are our specialty. Brandt's experience includes extensive work of this kind for the automotive, refrigeration, electrical, aircraft, and similar exacting industries. Brandt's strategic location near steel mills and rail, water and highway transportation helps meet delivery schedules. Why not tell us your needs and see if we can be of service.

CHARLES T. BRANDT, INC. 1700 RIDGELY ST. BALTIMORE 30, MD.



PACKARD SUNLIGHT MOTORS

We're Building More So You Can Build More

PACKARD SUNLIGHT MOTORS
for
compressors
washing machines
power-driven bench tools
ironers
milk separators
milking machines
furnace blowers
stokers
oil burners
water pumps
ventilators
and many other applications

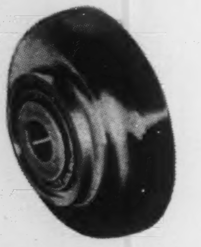
Packard Sunlight Motors are now produced in greater quantity to satisfy the growing demand for top quality power units in the appliance field. Increased production facilities in our new plant enable us to offer additional customers the opportunity to build trade acceptance and consumer good will with the efficiency and dependability of Packard Sunlight Fractional Horsepower Motors. Now you, too, can increase the quality and prestige of your products by using this great name in appliance motors to power them.

Packard
REG US PAT OFF
TRADE MARK

Packard Electric Division, General Motors Corporation, Warren, Ohio

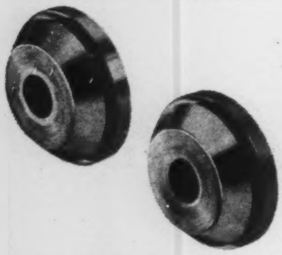
DEPENDABLE APPLIANCE MOTORS FOR THIRTY-TWO YEARS

Here's How 4 Industries Use HAYNES Alloy Parts to Keep Machines on the Job Longer



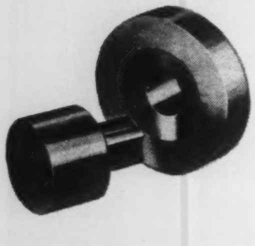
RAILROAD

Only one set of HAYNES STELLITE alloy burnishing rollers was required to burnish more than 100,000 axles. In eight years of hard service, the rollers needed no repair or maintenance, except lubrication.



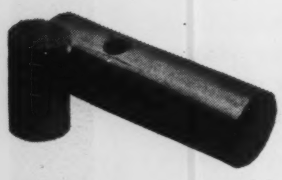
TIN FABRICATING

Seaming rolls, cast of HAYNES STELLITE alloy, give eight to ten weeks of service in the manufacture of tin cans. The steel rolls formerly used for this purpose lasted only two to three weeks.



FOOD PROCESSING

Valves and seats of HAYNES STELLITE J-Metal, used in equipment for homogenizing chocolate, are unaffected by the acids in the food or the abrasion and wire-drawing effect of high-speed, high-pressure operation. Since the alloy takes a high polish, its surface is readily cleaned.



DIE CASTING

Parts used in die-casting machines—such as this cylinder and piston—must resist the heat and corrosive action of molten metal. HAYNES STELLITE alloy parts give long, trouble-free service.

If you specify parts made of HAYNES alloys, you can be sure that your equipment will operate longer and at lower cost. This is because of the unique combination of properties offered by these alloys . . . outstanding resistance to severe abrasion, heat, and corrosion.

Since HAYNES alloys are hard, tough, and heat-resistant, they are ideal for machinery parts subjected to severe operating conditions. Finished parts can be furnished to specified tolerances and with polished surfaces, where needed. A number of standard parts are carried in stock; other parts can be made on order to your specifications. Our engineers will be glad to help you decide where HAYNES alloy parts can be used to advantage in your machinery. Just call or write to our nearest district office.

HAYNES TRADE-MARK *alloys*

Haynes Stellite Company
Unit of Union Carbide and Carbon Corporation
UCC
General Offices and Works, Kokomo, Indiana
Sales Offices
Chicago—Cleveland—Detroit—Houston—Los Angeles
New York—San Francisco—Tulsa

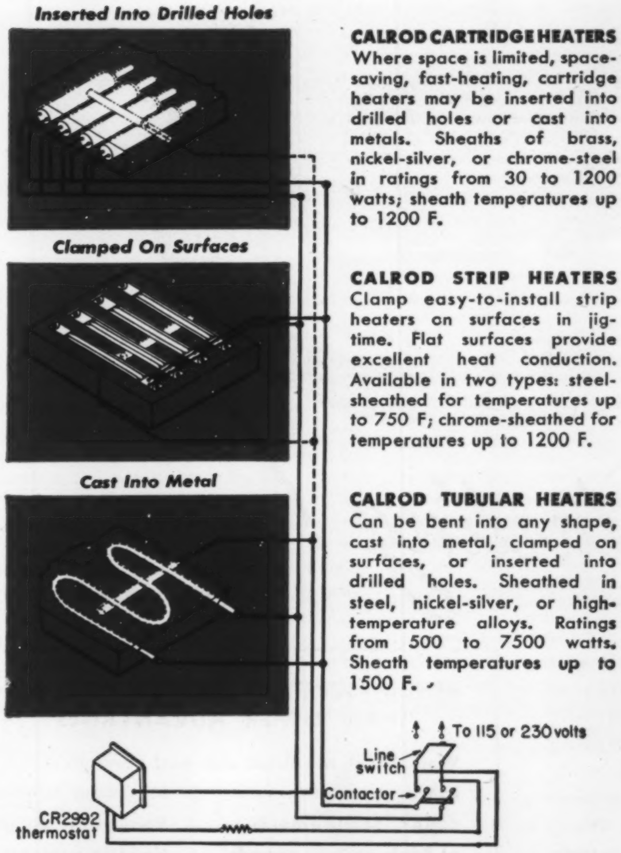
The trade-marks "Haynes" and "Haynes Stellite" distinguish products of Haynes Stellite Company.

KEROSENE LAMPS IN YOUR DRAFTING ROOM?

CERTAINLY NOT!

And General Electric Calrod* Heaters can solve your surface heating design problems in the same way you light your offices . . . electrically! Yet some designers are still trying to solve surface heating problems with equipment almost as antiquated as the kerosene lamp . . . when it is so easy to apply uniform, easy-to-control, surface heat with G-E Calrod Heaters like this . . .

*Reg. U. S. Pat. Off.



CALROD CARTRIDGE HEATERS
Where space is limited, space-saving, fast-heating, cartridge heaters may be inserted into drilled holes or cast into metals. Sheaths of brass, nickel-silver, or chrome-steel in ratings from 30 to 1200 watts; sheath temperatures up to 1200 F.

CALROD STRIP HEATERS
Clamp easy-to-install strip heaters on surfaces in jig-time. Flat surfaces provide excellent heat conduction. Available in two types: steel-sheathed for temperatures up to 750 F; chrome-sheathed for temperatures up to 1200 F.

CALROD TUBULAR HEATERS
Can be bent into any shape, cast into metal, clamped on surfaces, or inserted into drilled holes. Sheathed in steel, nickel-silver, or high-temperature alloys. Ratings from 500 to 7500 watts. Sheath temperatures up to 1500 F.

G-E Thermostat (CR2992) controls Calrod heaters accurately and effectively over a wide range of temperatures up to 750 F.

GENERAL ELECTRIC

Typical Surface-Heating Applications with General Electric CALROD Heaters

platens ● pre-shrinking machines ● packaging machines injection molding machines ● cigarette machines ● textile machinery ● bottle capping ● die heating ● embossing food-vending machines ● matrix scorching ● molding presses ● valve warming ● rubber molding machines ● roll heating ● sand drying ● aluminum extrusion ● paper machinery ● vulcanizing machinery ● tire recapping equipment

There is a G-E Calrod heater for virtually every surface-heating requirement and every surface. For best results, consult your G-E Heating Specialist before you design.

For valuable surface-heating ideas and application data, get your FREE COPY of the new publication, "HEATING SURFACES," GEA-5097. Just clip and mail the coupon.

MAKE THINGS "HOT"

Apparatus Department, Sect. C720-1
General Electric Company, Schenectady 5, N. Y.
Please send me a copy of your new, idea-packed publication, "HEATING SURFACES," GEA-5097.

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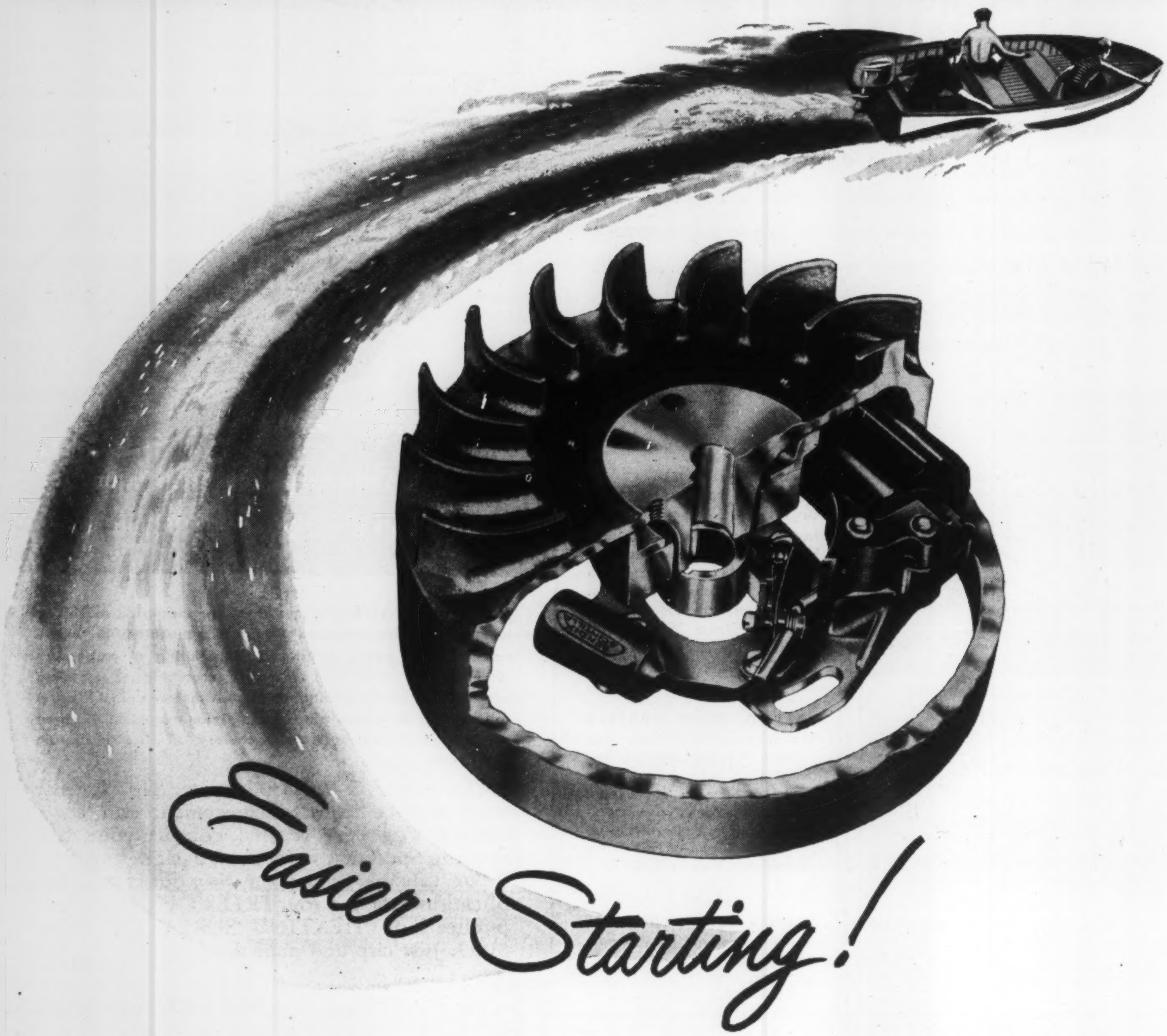
BENDIX-SCINTILLA FLYWHEEL-TYPE MAGNETO

FOR 1- AND 2-CYLINDER ENGINES


Easier Starting!

Whether it is an outboard motor or a portable generator, a power saw, or a power lawn mower—more and more manufacturers and users of one or two-cylinder engines are turning to Bendix-Scintilla Flywheel-type Magnetos for easier starting under all operating conditions. Even at low cranking speeds, these magnetos provide all the high-tension sparks needed for quicker, more dependable starting. When you specify Bendix-Scintilla Flywheel-type Magnetos, you know that you're getting the benefit of 25 years experience in building aircraft engine ignition.

BENDIX-SCINTILLA BRINGS YOU ALL THESE OTHER ADVANTAGES

Waterproof moulded coil and condenser . . . Lower operating cost . . . Minimum lubrication requirements . . . Peak efficiency at high or low speeds . . . Light in weight.

For Further Details and Suggested Applications,
SEND FOR OUR NEW ILLUSTRATED BOOKLET "THE K-MAGNETO"

BENDIX
SCINTILLA

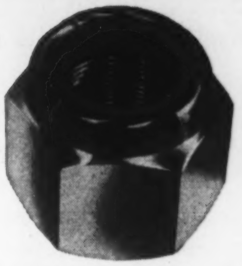
SCINTILLA MAGNETO DIVISION of
SIDNEY, NEW YORK
Export Sales: Bendix International Division, 72 Fifth Avenue, New York 11, New York

Bendix
AVIATION CORPORATION

Clutch Adjustment WITH ONE HAND

SAVES TIME...MONEY

HYSTER HYSTAWAY



THE FAMOUS RED ELASTIC COLLAR IS VISIBLE EVIDENCE OF LOCKING SECURITY

Threadless and permanently elastic, it provides these 4 outstanding features:

1. Protects against nuts loosening due to VIBRATION
2. Keeps locking threads CORROSION FREE
3. Provides for accurate BOLT LOADING
4. Seals against LIQUID LEAKAGE along the bolt threads

—the Red Elastic Collar helps JUMP PRODUCTION...CUT COST!

The nut and jam nut combination formerly used on the clutch adjustment rod of the Hystaway—tractor-mounted excavator manufactured by the Hyster Company at Portland, Oregon, had two disadvantages: (1) two wrenches were required to adjust the clutch (one to hold the first nut, and one to loosen and reset the jam nut); and, (2) it was difficult to get two hands through the limited frame opening.

After exhaustive experimentation, the Company adopted Elastic Stop Nuts. Now clutch adjustment can be made quickly, easily and *exactly—with one hand.*

Further, since Elastic Stop Nuts lock in position anywhere on a bolt or stud, only one adjustment is usually necessary—the first. Once this adjustment is made, the Red Elastic Collar maintains that precise setting permanently. Neither vibration nor impact will shake the nuts loose. Also, Elastic Stop Nuts keep bolt and nut threads rust-free . . . seal against liquid seepage along bolt threads . . . do not damage the threads. And, of course, Elastic Stop Nuts are re-usable.

HERE'S A CHALLENGE: Send us complete details of your toughest bolted trouble spot. We'll supply test nuts—FREE, in experimental quantities. Or, if you want further information, write Elastic Stop Nut Corporation of America, Union, N. J. Representatives and Agents are located in many principal cities.

ESNA
TRADE MARK

ELASTIC STOP NUTS

HIGH TENSILE · ANCHOR · WING · SPLINE · CLINCH · GANG CHANNEL · NYLON CAP

OVER 450 TYPES AND SIZES IMMEDIATELY AVAILABLE FROM STOCK

PRESSURE LOADING

in a hydraulic pump

...provides volumetric efficiencies up to 97%!...provides torque efficiencies up to 90%!
...assures these efficiencies over a longer service life!

Pressure Loading
by
Pesco
Pesco Products Division
Borg-Warner Corporation
CLEVELAND, OHIO

This booklet explains
PRESSURE LOADING . . . write
for your copy today.

ONLY Pesco HYDRAULIC PUMPS GIVE YOU PRESSURE LOADING

Pressure Loading is a Pesco patented principle of hydraulic pump design which utilizes pressure from the discharge of the pump to maintain a minimum end clearance between gear and bearing faces. This automatically compensates for wear.

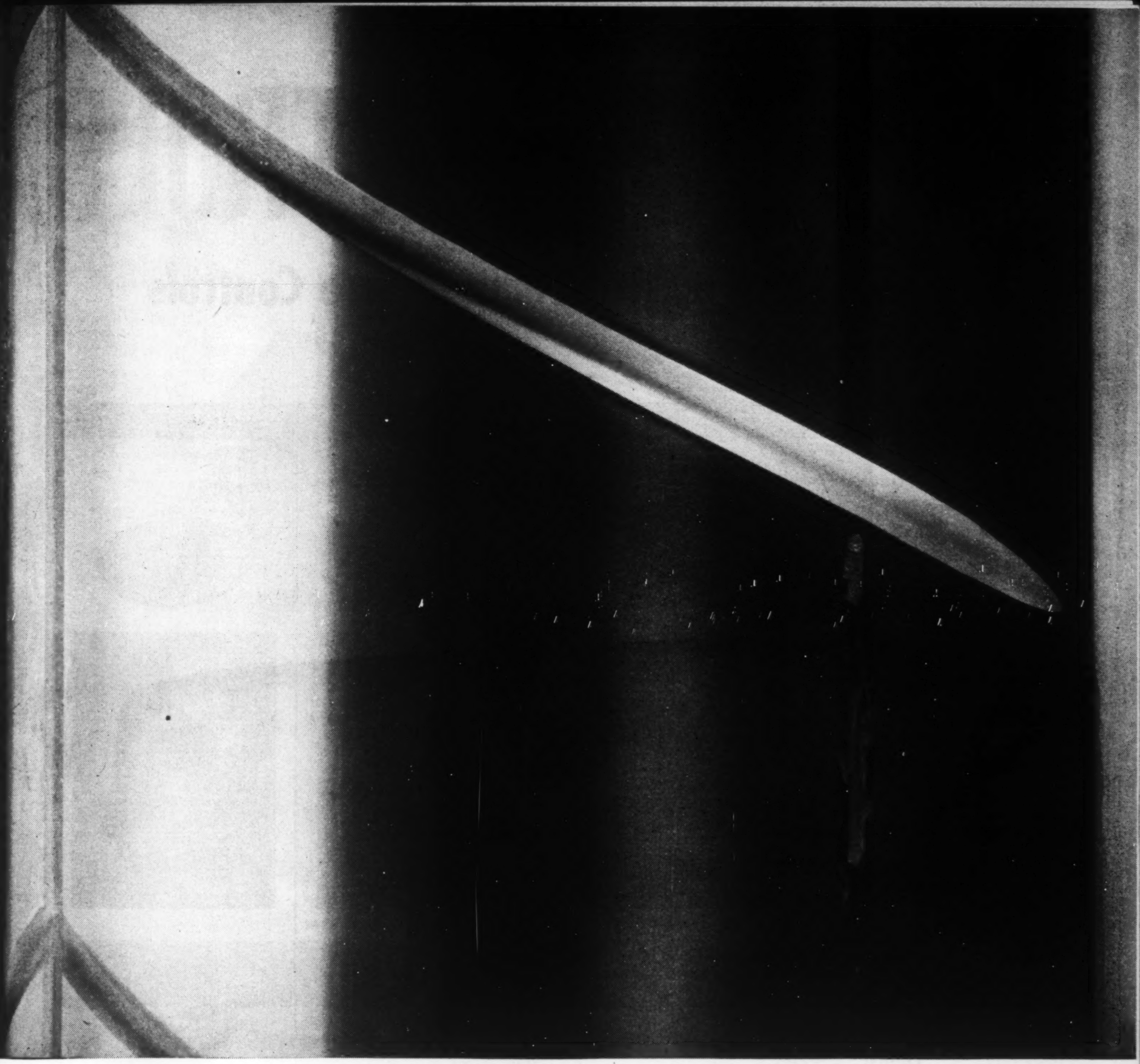
Pesco hydraulic pumps with *Pressure Loading* will not "freeze" under normal load conditions. They have an unusually long service life. They require minimum maintenance. Do not require micrometer fits. They guarantee highest possible efficiencies under all operating conditions.

Only Pesco hydraulic pumps have *Pressure Loading*. If the design of your product calls for the use of hydraulic pumps . . . or other hydraulic equipment . . . it will pay you to send for your copy of the free booklet, "Pressure Loading by Pesco".

OTHER ADVANTAGES OF PESCO PRESSURE LOADED HYDRAULIC PUMPS

1. **Provides uniform rate of fluid flow regardless of variations in load, in viscosity of hydraulic fluid, or in temperature.**
2. **Permits use of smaller pump for a given installation.**
3. **Accomplishes more work per unit of energy expended.**

Pesco PRODUCTS DIVISION
BORG-WARNER CORPORATION
11610 Euclid Ave. - Cleveland 6, Ohio
MANUFACTURERS OF BW **SUPERCHARGERS**



SUPERFINISH...

modern preventive for metal "skin wounds"!

This *unretouched* enlargement shows the surface of a spindle quill—ground and chrome plated. It was scored and damaged as the machine was jarred in shipment. Had the part been Superfinished *before* plating, the soft underlying "smear metal" caused by grinding heat would have been removed, leaving a hard surface far less susceptible to such "skin wounds."

Superfinishing is a real economy wherever maximum bearing life is desired. If you don't have the textbook, "Wear and Surface Finish," request it on your company letterhead.

GISHOLT MACHINE COMPANY
Madison 10, Wis.

GISHOLT

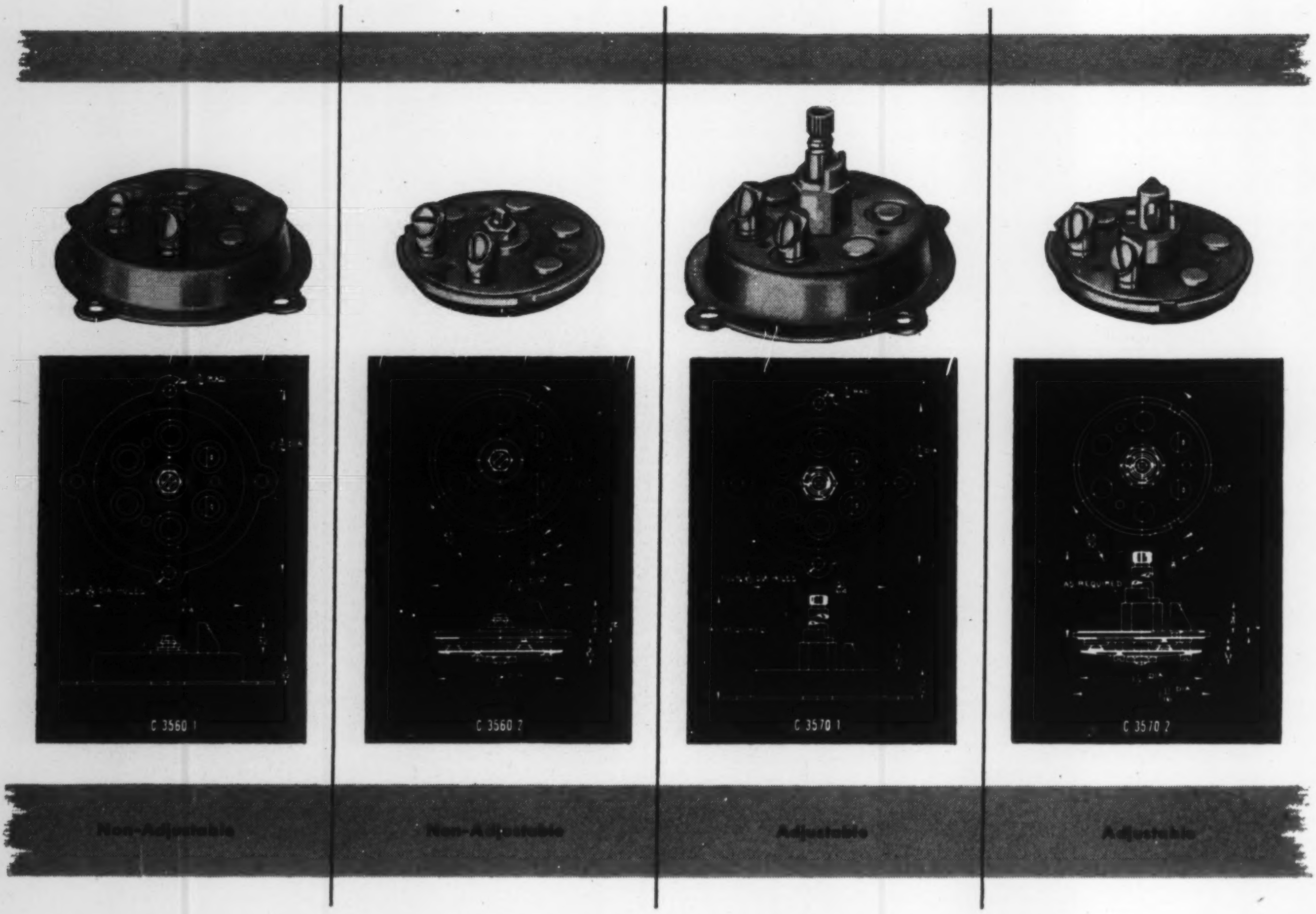
THE GISHOLT ROUND TABLE

represents the collective experience of specialists in machining, surface-finishing and balancing of round and partly round parts. Your problems are welcomed here.

TURRET LATHES • AUTOMATIC LATHES • SUPERFINISHERS • BALANCERS • SPECIAL MACHINES

KLIXON *Thermo Snap* CONTROLS

Give You Positive Temperature Controls



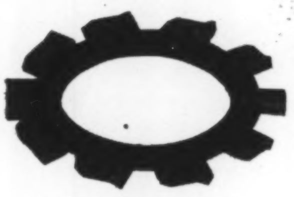
Built-in as an inherent part of the product, Klixon Thermo-Snap Controls give you accurate, dependable temperature control. Actuated by the scientifically calibrated Spencer disc, they open the circuit with a quick clean break; close the circuit to a solid make. Small and compact, their operation is unaffected by shock, motion or vibration.

Klixon Thermo-Snap Controls are used in such equipment as space heaters, sterilizers, electrical appliances, radio and broadcast equipment, unit heaters, etc. Applications include—fuel delay switches, ignition cut-offs, purge switches, fan switches and high limit controls, temperature controls, tube and rectifier cooling controls.

Investigate Klixon Thermo-Snap Controls for your products. Bulletin PR 116 gives complete information. Write for a copy.

KLIXON

SPENCER THERMOSTAT *Division Metals & Controls Corp.* **2503 FOREST ST., ATTLEBORO, MASS.**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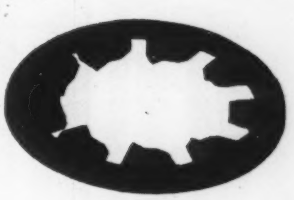
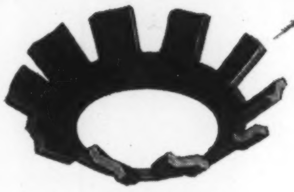
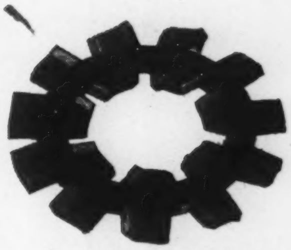
EverLOCK


Standard Internal
EverLOCK


Standard 80° Countersunk
EverLOCK


Standard Internal-External
EverLOCK

WITH WIDE CHISEL EDGES

An edge provides more traction than a point. That principle applied to *multiple* wide chisel edges gives EverLOCK Washers their unmatched ability to hold against vibration, strain, expansion and contraction.

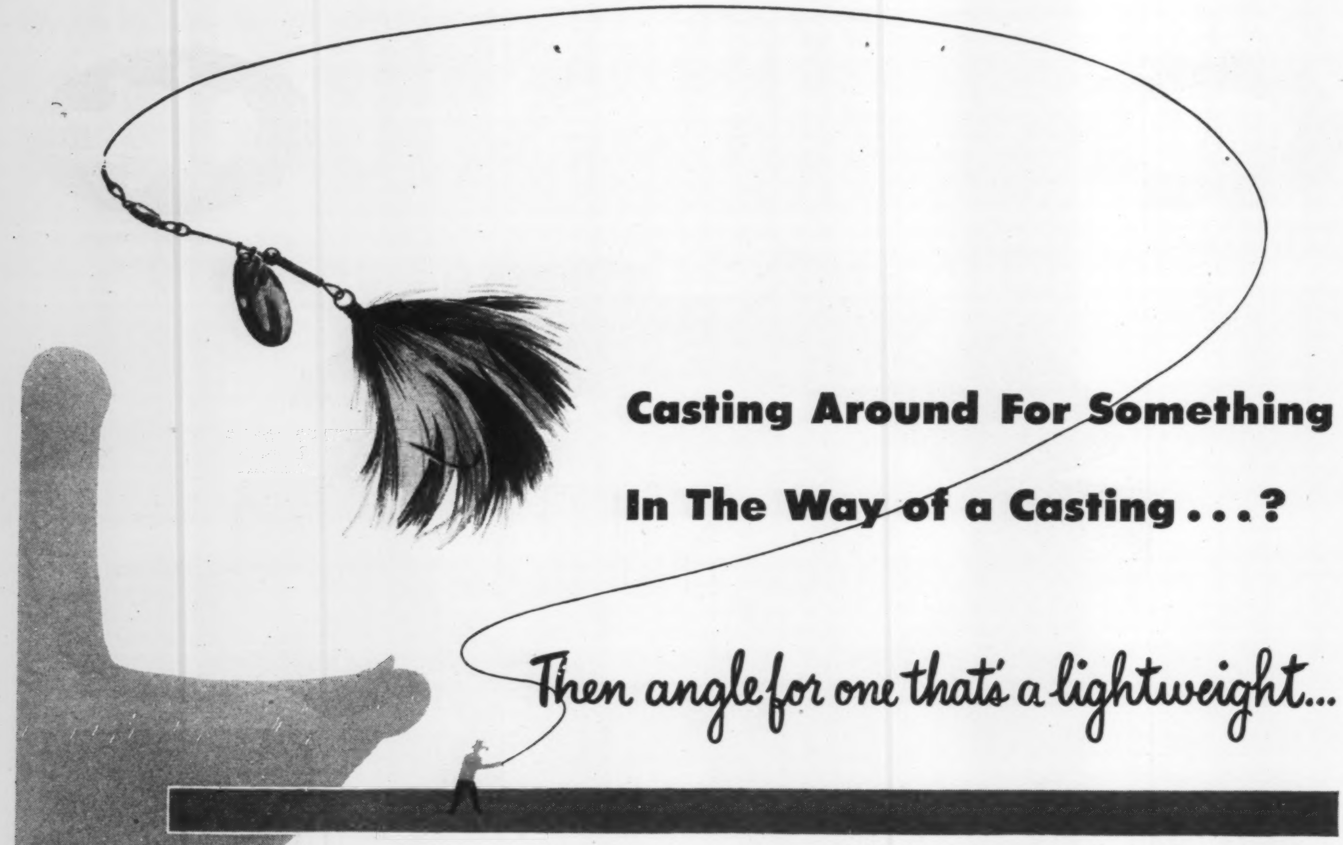
EverLOCK's multiple chisel edges are forced into the contiguous faces of both work and nut by powerful spring tension, assuring full use of the added gripping area.

EverLOCKS can be applied rapidly and easily . . . cut assembly time and labor costs . . . eliminate all hazards of stretched bolts and distortion of threaded parts. Write for full particulars.

Ever LOCK WASHERS

THE WASHER THAT HAS THE EDGE

THOMPSON-BREMER & CO. 1636 W. HUBBARD STREET • CHICAGO 22, ILLINOIS



Casting Around For Something In The Way of a Casting . . . ?

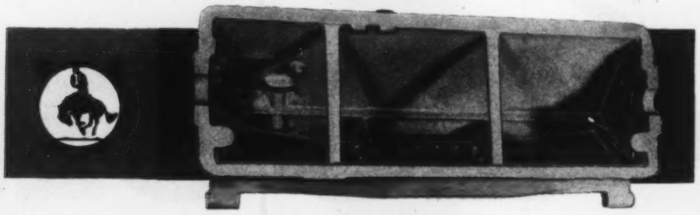
Then angle for one that's a lightweight...

Like Well-Cast aluminum or magnesium castings . . . machining goes as smooth as a breeze. They're Light (magnesium castings are 75% lighter than iron—aluminum castings 35% lighter). They're tough as a hickory nut . . . and they move through production with the greatest of ease—minimum trucking, minimum hoisting.

This, plus a product that's out in front because it's modern —because it's lightweight, featherweight.

Wellman can show you new ways to put magnesium and aluminum castings to work on your product. Their 37 years of know-how in the light metal castings field makes your problem their pleasure. Write for our Catalog No. 47.

WELL-MADE PATTERNS



Aluminum bus engine part

THE WELLMAN BRONZE & ALUMINUM COMPANY

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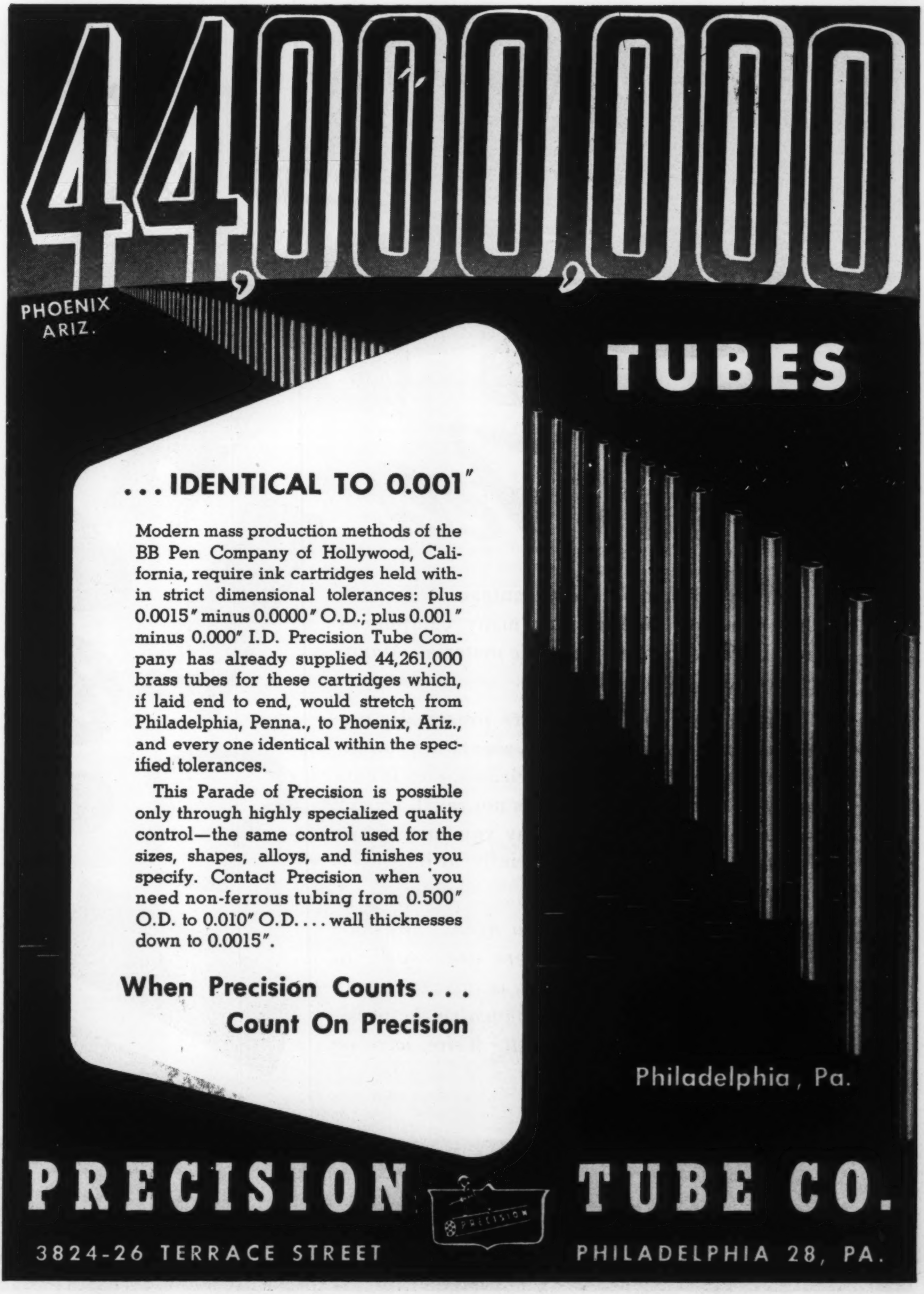

44,000,000 TUBES

. . . IDENTICAL TO 0.001″

Modern mass production methods of the BB Pen Company of Hollywood, California, require ink cartridges held within strict dimensional tolerances: plus 0.0015″ minus 0.0000″ O.D.; plus 0.001″ minus 0.000″ I.D. Precision Tube Company has already supplied 44,261,000 brass tubes for these cartridges which, if laid end to end, would stretch from Philadelphia, Penna., to Phoenix, Ariz., and every one identical within the specified tolerances.

This Parade of Precision is possible only through highly specialized quality control—the same control used for the sizes, shapes, alloys, and finishes you specify. Contact Precision when you need non-ferrous tubing from 0.500″ O.D. to 0.010″ O.D. . . . wall thicknesses down to 0.0015″.

When Precision Counts . . .
Count On Precision

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Western Felt applications are practically unlimited—in isolating vibration, absorbing sound, filtering liquids, retaining lubricants, etc. It cuts readily to any form . . . and does not ravel, fray or lose its shape. In whatever way you may use it —Western Felt can add materially to improved performance of a product.

Name the characteristics you need . . . Western Felt engineers are ready to work with you in answering any problems that involve the possible use of felt. Write, wire or phone today.

Acadia Synthetic Division, Processors of Synthetic Rubber and Plastics: Sheets, Extrusions and Molded Parts.

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LARGEST INDEPENDENT MANUFACTURERS AND CUTTERS OF WOOL, HAIR AND JUTE FELTS

MODERN, COMPACT R & M POWER

Meets the needs of Functional Design

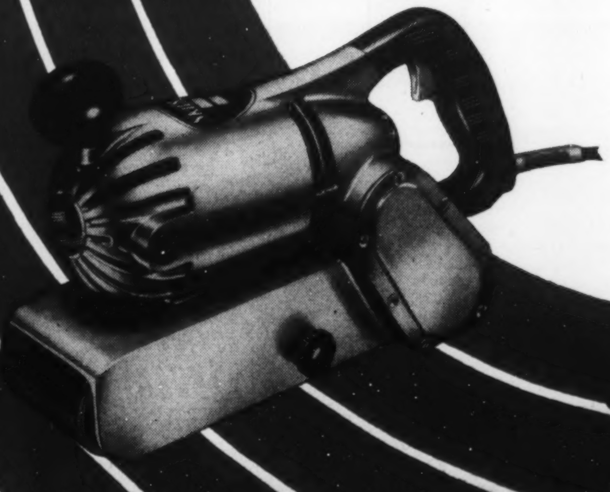
SKILSAW, INC., USES ROBBINS & MYERS MATCHED MOTOR PARTS IN VERSATILE ELECTRIC *SKIL* TOOLS!

SKILSAW, Inc., is a *long-time* user of R & M Matched Motor Parts—and for good reasons. By working together, SKILSAW and R & M have simplified Skil Tool design. And *even more important* is the well-earned confidence in long, dependable service. Capable, compact R & M power makes friends all along the line—from drafting board to *on-the-job.*

AS YOU WANT IT. R & M Matched Motor Parts are convenient and easy to use. First, because they meet the limitations of *small size,* shape, and weight. Second, because all motor types are *dimensionally interchangeable.* The complete line of standardized elements affords wide, precise selection, and R & M will design and produce special parts that are made *just for you.*

WHERE YOU WANT IT. Wherever powering is a problem—on portable equipment or larger installations—you can look to R & M for serviceable, *sound ideas.* R & M Matched Motor Parts in fractional and integral ratings for normal or high frequencies, and complete R & M motors from 1/200 to 30 horsepower, all reflect *progressive foresight* backed by long experience.

- For literature, or cooperative engineering aid that *others* have found so helpful, write *Robbins & Myers, Inc., Motor Div., Dept. E-39, Springfield 99, Ohio.*

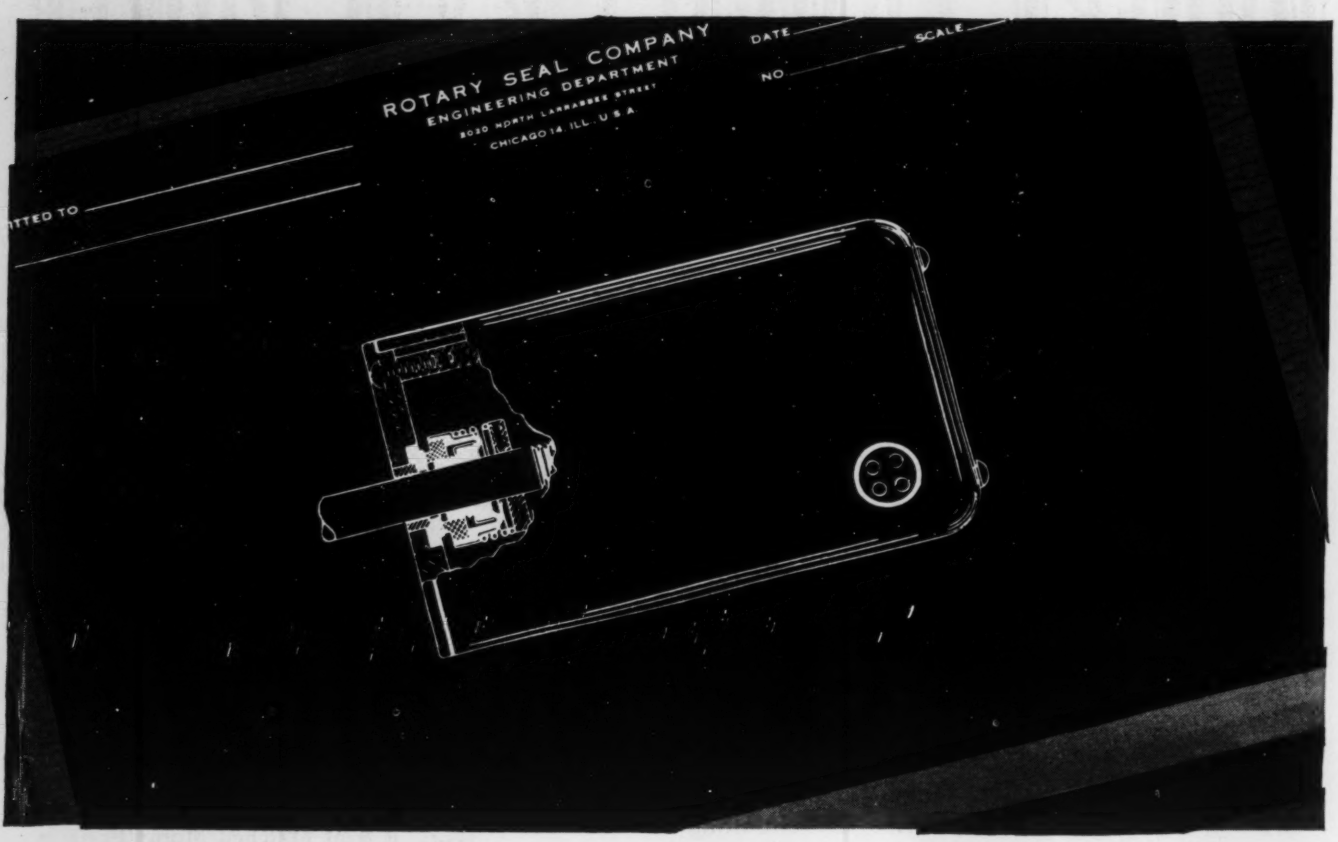


Shown are a representative SKIL Drill, SKIL Belt Sander, and SKIL Saw, a few of the many R & M-powered tools made by SKILSAW, Inc., Chicago 30.

BUILD IT LIGHTER, SMALLER, BETTER-LOOKING, WITH

R & M MATCHED MOTOR PARTS

IT TAKES A SURE HAND TO TURN THE ODD TRICK—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ENGINEERING DEPARTMENT
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but ROTARY SEAL experience means *Certainty!*

Shaft sealing problems can be highly critical—such as the one illustrated, involving a remarkably ingenious adaptation of the famous ROTARY SEAL principle to insure unvarying performance in very delicate radio equipment under a wide range of difficult conditions. Such problems are tricky. Solving them takes the practiced hand of a specialist, working from the background of vast practical experience accumulated by a pioneer in the field.

The sure hands of ROTARY SEAL engineers—thoroughly schooled in every aspect of shaft sealing through years of working with the makers of all kinds of equipment and devices in every field you can think of—can turn the odd trick, if necessary, for *your* special requirement. For best results all along the line, call ROTARY SEAL in at the drawing-board stage when planning new equipment in which *sure* shaft sealing is a factor.

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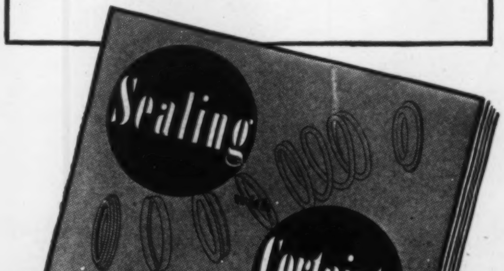
is the original approach to a practical solution of a universally troublesome problem. Our booklet "Sealing with Certainty" explains and illustrates the principle. We're glad to send it to you without obligation.


Sealing
with
Certainty
on rotating shafts

THE ROTARY SEAL COMPANY
mechanical seals for rotating shafts

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CHICAGO 14, ILLINOIS, U.S.A.

HELPFUL LITERATURE

FOR DESIGN EXECUTIVES

73. Retaining Rings
Waldes Kohinoor, Inc.—12-page illustrated catalog No. 4K-6 describes types of Truarc retaining rings, their applications and performance. Rings maintain their circularity and hug bottom of grooves tightly at all times.

74. Projection Welding Pads
Ohio Nut & Bolt Co.—4-page illustrated bulletin No. 485 describes line of weld pads which provide additional thickness for sheet metal sections where drilled or tapped holes are required that can be located only after pads have been welded in place. Pads are used also for mountings and as spacers.

75. Induction Motors
Reliance Electric & Engineering Co.—4-page illustrated bulletin C-118 shows construction features and outlines operating characteristics of type AA induction motors which are available in frames 203 to 405.

76. Bearing Bronze
Bearium Metals Corp. — 6-page illustrated folder lists frictional properties of Bearium metal, available bar stock sizes and individual castings. Photomicrographs show structure and lead distribution achieved in production of this metal which adapt it for use in bearings, bushings, thrust washers and other parts having rubbing friction.

77. Cast Iron
Meehanite Metal Corp.—18-page illustrated bulletin No. 26 is entitled "Formulas for Computing Maximum Stresses and Deflection in Circular Flat Plates." Tables, charts and other data serve to amplify text.

78. Fastening Devices
Eaton Mfg. Co., Reliance Div.—20-page illustrated bulletin No. 4k/3 describes Reliance snap, bearing, lock and retainer rings; Eaton Springtite lock washers; and Reliance spring lock washers. Complete dimensional data, design considerations and application data are included.

79. Wire Cloth & Screen
Korb-Pettit Wire Fabrics & Iron Works, Inc.—44-page illustrated catalog No. 36 describes square opening space screens, types of weaves and crimps, double-crimp wire cloth, square mesh market grade wire cloth and extra fine wire cloth. Engineering information is included to simplify selection and application of proper type, material and size.

80. Hydraulic Cylinders
Gerotor May Co.—20-page illustrated bulletin No. 103 covers standard hydraulic cylinders and contains diagrams and information to aid in laying out circuits. Engineering data are included on available mounting styles, 2-to-1 cylinders in diameters from 2 to 10 inches, cushioned cylinders, displacements and theoretical forces.

81. Cold-Rolled Strip Steel
Cold Metal Products Co.—4-page illustrated bulletin "CMP Thinsteel" covers steel grades, tempers, finishes and coil weights of carbon, spring and stainless steel precision cold-rolled strip which is produced in widths up to 23$\frac{11}{16}$ inches.

82. Silicone Fluids
Dow Corning Corp.—36-page illustrated publication "Dow Corning Silicone Notebook, Fluid Series No. 3" discusses properties of DC 200 silicone fluids which are suitable for use as damping and hydraulic media, liquid dielectrics, special purpose lubricants, additives, impregnants and coatings.

83. Metal Products
Scovill Mfg. Co.—90-page illustrated bulletin "Masters of Metal" shows facilities of company that are available to produce parts that it can forge, stamp, head, draw, machine, wireform and point or assemble from brass, bronze, nickel-silver alloys, steel, aluminum, zinc or other metal. Typical parts produced by various methods are shown; and engineering, manufacturing, assembling and inspection procedures are covered.

84. Wire Rope
Jones & Laughlin Steel Corp.—95-page illustrated bulletin "Wire Rope Is a Machine" contains detailed instructions for installing and using wire rope, and selecting correct type for specific jobs. Cataloged are available rope constructions; standard fittings, slings and splicing service; and general recommendations on rope for use on standard equipment.

85. Electrical Brushes
United States Graphite Co.—40-page illustrated catalog No. B-49 contains complete listings of sizes, types and materials used in brushes for electrical machines. Brushes for use as original equipment and for replacement are described. Engineering data to aid in selection and application of brushes are presented.

86. Electronic Control
R-S Products Corp., Electronic Div.—8-page illustrated bulletin "Leveltronic" describes new electronic circuit using hot cathode thyratron control for liquid level and interface, pressure and temperature applications. Schematic application drawings, data on accessories and specifications are included.

87. Cold Cast Iron Arc Welding
Eutectic Welding Alloys Corp.—6-page illustrated folder on Eutectrode 24/49 tells how this electrode can be used for arc welding of cast iron without need of preheating and at low current. Also described is CutTrode electrode for cutting all types of metals, either thick or thin.

88. Bearing Application
New Departure Div., General Motors Corp. —20 page illustrated engineering service booklet "Outline of Procedure in Bearing Application" briefly describes principal steps in developing successful ball bearing mounting.

89. Metal Spinning
Craft Metal Spinning Co.—4-page illustrated bulletin describes manufacturing facilities which are available to spin all gages and types of metal including stainless steel in diameters up to 84 inches. Annealing, pickling and polishing service is offered also.

90. Bearing & Spindle Design
SKF Industries, Inc. — 64-page illustrated catalog No. 272 deals with machine tool bearing and spindle design. Engineering principles are discussed; and tolerance, bearing and load tables as well as shaft and housing dimensions are included. Bearing applications in each type of machine and spindle are covered in detail.

91. Lubricating Equipment
Aro Equipment Corp.—18-page illustrated catalog No. 148 supplies information on low and high pressure lubricators, drum cover type lubricators and spring packers, power and lever guns, transfer pumps and other lubricating equipment as well as grease fittings.

92. Production Facilities
Connecticut Telephone & Electric Div., Great American Industries, Inc.—20-page illustrated brochure "Components of Quality" depicts facilities of engineering department, machine shops and continuous process departments for production of component parts.

FOR MORE INFORMATION

on developments in "New Parts" and "Engineering Department" sections—or if "Helpful Literature" is desired—circle corresponding numbers on either card below.

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93. Synthetic Rubber Packings

E. F. Houghton & Co.—110-page illustrated "Handbook on Synthetic Rubber Packings" contains general information on classes and types of packings, application and design of fabricated and homogeneous packings, and use of leather back-up washers. Design data are included on use of packings in all types of hydraulic controls and equipment.

94. Sound Control

Johns-Manville—16-page illustrated bulletin entitled "Sound Control" deals with noise quieting, acoustical correction and vibration isolation. Various materials which have solved problems of sound control and typical applications of these materials are covered. Pertinent data on size, weight and sound absorption of different products are presented.

95. Flat Top Chain Belts

Chain Belt Co.—16-page illustrated bulletin No. 47-15 gives details on Rex TableTop chain belt which features simple one-piece link, wide bearing on sprocket, easy detachability, elimination of coupler links, easy cleaning and smooth operation.

96. Electronic Air Filters

American Air Filter Co.—12-page illustrated bulletin No. 257 deals with Electro-PL dry type electronic air filter which is basically an electronic precipitator without ionizing unit but using electrostatically charged Airmat paper.

97. Precision Spindles

Pope Machinery Corp.—4-page illustrated bulletin No. S-2 presents information on various types, designs and sizes of precision spindles for surface grinding, internal grinding, milling, boring and similar operations.

98. Automatic Controls

General Controls Co.—52-page illustrated catalog No. 52E contains complete data on automatic pressure, temperature and flow controls. Included are thermostats, gas controls, package sets, strainers, transformers, magnetic valves, relays and motor valves.

99. Hydraulic O-Rings

Crane Packing Co.—8-page illustrated engineering manual "John Crane Hydraulic 'O' Rings" contains tabulations of compound specifications, dimensional standards and data on applications and installations of O-rings.

100. Belting & Matting

Buckner Process Co.—6-page illustrated folder "Lion Paw" discusses functions of Lion Paw conveyor belting, transmission belting and safety matting. It reveals how impregnation process provides great flexibility, durability, abrasion resistance and high coefficient of friction.

101. Chromium Plating

Chromium Corp. of America—36-page illustrated Catalog No. 27 outlines advantages of chromium plating and describes performance that can be expected under known operating conditions. Successful applications of industrial chromium plating and details of Crodon plating service are discussed.

102. Hydraulic Pumps & Valves

Racine Tool & Machine Co.—8-page illustrated booklet "Racine Variable Volume Hydraulic Pumps and Hydraulic Valves" discusses construction and features of hydraulic equipment designed for working pressures up to 1000 pounds per square inch.

103. Broaching Machines

Oilgear Co.—12-page illustrated bulletin No. 22001 deals with Cyclematic broaching machines which feature automatic tool handling, work centralizing and work ejection; positive tool and work lubrication; variable cutting and return speeds and Oilgear variable delivery pumps.

104. Machine Tool Equipment

Allis-Chalmers Mfg. Co.—8-page illustrated bulletin No. 25B7110 presents data on motors, drives, controls and coolant pumps for use on lathes, planers, grinders, presses and chucking, milling and boring machines.

105. Sprockets & Drives

Cullman Wheel Co.—80-page illustrated catalog No. 48 contains helpful technical data on roller block and silent chain, sprockets, reducers and punch press drives. Elaborate specifications enable buyer to select his requirements readily.

106. Copper & Copper Alloys

American Brass Co.—28-page publication No. B-34, second edition, lists most generally used Anaconda alloys together with all applicable specifications, and lists specifications in numerical order with brief description of materials as to grade, type, temper, anneal, etc.

107. Air & Hydraulic Data

Miller Motor Co.—22 x 34-inch wall chart and 8½ x 11-inch data sheet give data on air and hydraulic pressure and flow. Push-pull stroke pressures for various cylinder sizes operating at pressures from 50 to 3000 pounds per square inch; oil and air consumption of hydraulic and air cylinders with 1½ to 20-inch bores; pipe sizes and frictional losses are given in chart form.

108. Carbon-Graphite Specialties

Stackpole Carbon Co.—44-page illustrated "Stackpole Carbon Specialties" booklet tabulates engineering and production data on numerous carbon and graphite specialties such as tube anodes, battery carbons, electrical contacts, electrodes, friction segments, clutch rings, bearing materials, carbon piles, molds and dies.

109. Rubber

B. F. Goodrich Chemical Co.—16-page illustrated booklet "Everywhere in Industry" contains useful data on Hycar American rubbers. Compounding, fabricating, and properties of Hycar vulcanizates, phenolic blends and cements are discussed.

110. Flexible Couplings

Climax Flexible Coupling Co.—4-page illustrated bulletin No. 51 describes standard, light and heavy duty flexible couplings for all types of direct-connected drives. Dimensions, ratings and application data are included.

111. Hydraulic Pumps

Denison Engineering Co.—8-page illustrated bulletin No. P-1 is descriptive of high pressure, high volume Hydroilic pumps of axial piston, constant displacement type for services up to 5000 pounds per square inch. Capacities range to 32 gallons per minute.

112. Stainless Steel Data

Timken Roller Bearing Co., Steel & Tube Div.—12-page illustrated technical bulletin No. 33 presents data on martensitic stainless steels for applications requiring corrosion and heat resistance. AISI types covered are 405, 410, 416 and 420. Chemical composition, uses, heat treatment, structures, physical properties, corrosion resistance and other subjects are discussed.

113. Welding Design

Lincoln Electric Co. — 16-page illustrated technical article "Design for Welding" by T. B. Jefferson discusses design considerations involved in structures, machines, parts, frames and other components which are to be of welded construction.

114. Contacts & Brushes

Superior Carbon Products, Inc.—4-page illustrated bulletin No. S-104 shows typical molded silver electrical contacts and silver-graphite brushes. Characteristics of available grades of materials are listed, together with recommended uses.

115. Stainless Steel

Joseph T. Ryerson & Son, Inc.—32-page illustrated booklet "Allegheny Metal in the Meat Industry" explains advantages obtainable through use of this stainless steel in meat packing and processing plants. Applications to equipment are shown.

116. Multiple V-Belts

B. F. Goodrich Co.—4-page illustrated bulletin No. 2170 describes construction of Multicord and Grommet Multi-V belts and gives belt numbers, sizes and pitch lengths.

117. Alloy Bar Stock

Titan Metal Mfg. Co.—6-page illustrated bulletin gives alloy compositions, weights and dimensions of rectangular and square bars made of eight different brass and bronze alloys.

118. Welding Instruction

Air Reduction Sales Co.—6-page illustrated bulletin ADG1084 briefly reviews contents of five welding and cutting instruction books. Two volumes are devoted to arc welding and two to oxyacetylnee welding and cutting. Fifth book is 300-page definitive work entitled "Manual of Design for Arc Welded Steel Structures."

119. Automatic Production Control

Reeves Pulley Co.—16-page illustrated booklet No. GN-487 discusses functions of automatic production control and means of applying it to production machinery through use of variable speed transmission and Motodrive in conjunction with controls.

120. Molded & Extruded Plastics

Elmer E. Mills Corp.—48-page illustrated catalog "Injection Molded and Extruded Plastics" covers company's production facilities, presents production data on plastic materials, describes Mills-Plastic tubing and fittings, and discusses variety of thermoplastic materials.

M. D. Numbers

1	21	41	61	81	101
2	22	42	62	82	102
3	23	43	63	83	103
4	24	44	64	84	104
5	25	45	65	85	105
6	26	46	66	86	106
7	27	47	67	87	107
8	28	48	68	88	108
9	29	49	69	89	109
10	30	50	70	90	110
11	31	51	71	91	111
12	32	52	72	92	112
13	33	53	73	93	113
14	34	54	74	94	114
15	35	55	75	95	115
16	36	56	76	96	116
17	37	57	77	97	117
18	38	58	78	98	118
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20	40	60	80	100	120

MACHINE DESIGN 3-49

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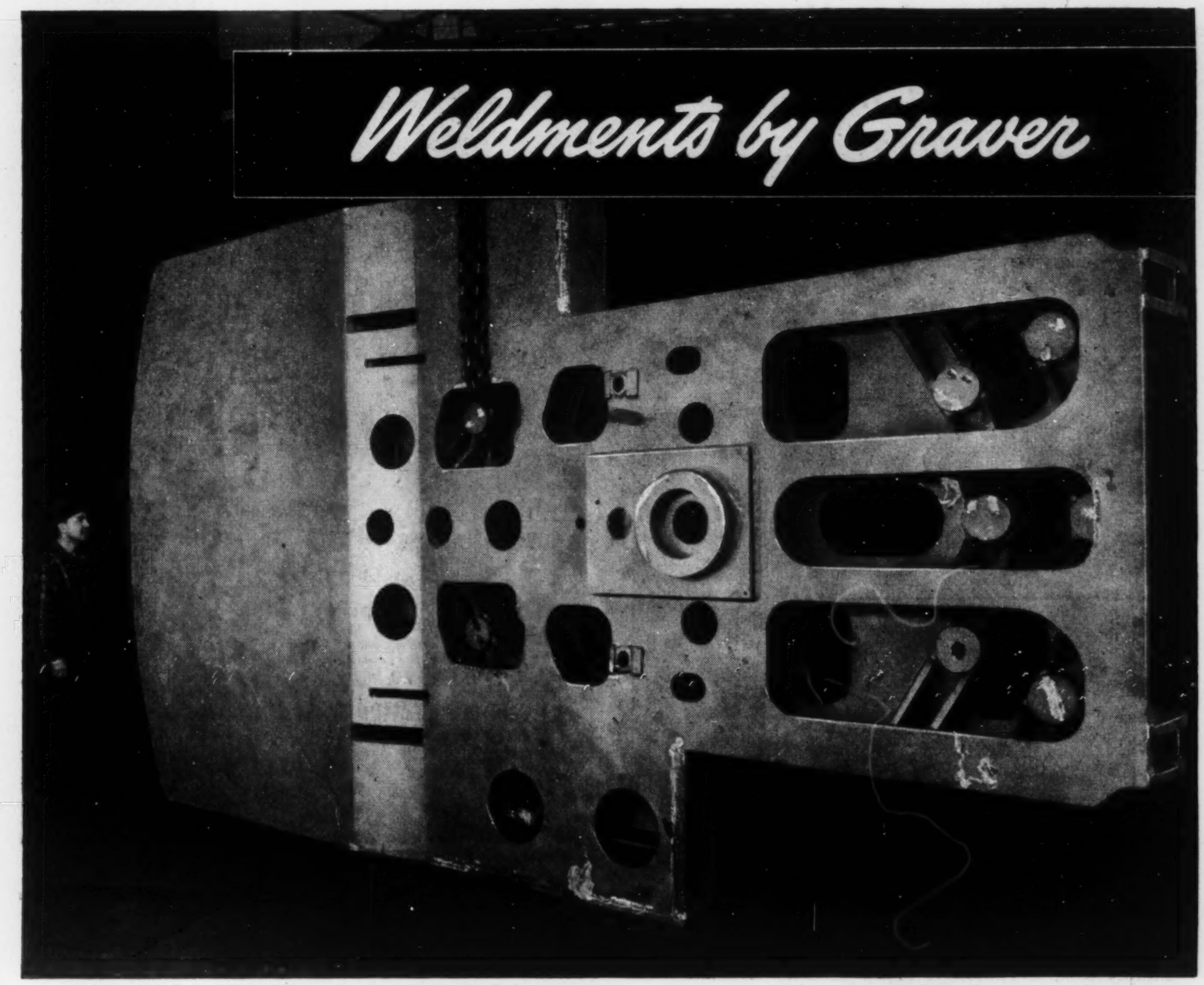
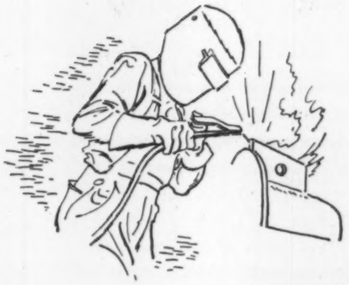


BASIC PLANNING FOR HEAVY MACHINES



Take this nine and one-half ton bed plate for a heavy-duty crane, for example. Sheared and flame-cut of steel plate, then joined through welding to become a rugged one-piece structure, it puts strength where strength is needed and eliminates useless weight.

In structures like this one . . . or in any machine base, press frame, large gear blank, engine base, housing or other heavy-duty unit . . . Graver weldments offer production economies that mean profits to you. Working to close tolerances, much final machining is eliminated. There are no pattern expenses. Changes may be made at any time . . . during or after fabrication. Sub-assemblies and attachments may be welded, not bolted, to the structure. Web cross-sections may be reduced. Expensive materials may be used only for certain surfaces, the remainder being ordinary carbon steel. For single units or for production runs, these are the advantages of Graver weldments.

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GRAVER TANK & MFG. CO., INC.

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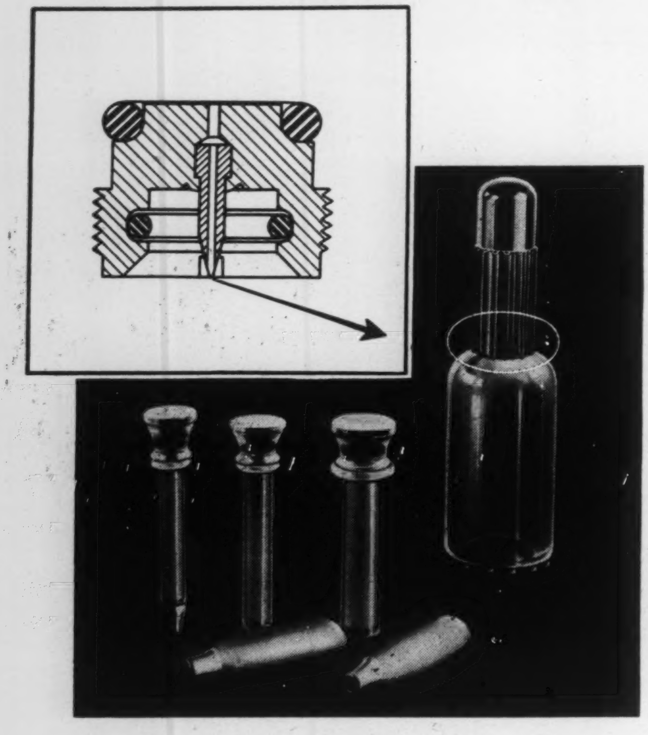

Simply this, Cryotherapy is the medical treatment of skin disorders by the use of carbon dioxide snow. Now this treatment is made practical—simple—effective—and economical by the invention of the Kiddie Dry Ice Machine. This dry ice machine is made possible by the use of LINEAR "O" rings.* The "O" rings act as a seal between the neck of the gas cylinder and the cylinder piercing assembly. This assembly is in turn sealed to the discharge orifice with another "O" ring used as a static seal on three surfaces. LINEAR "O" rings are performing successfully on the Kiddie Dry Ice Machine at pressures of 900 PSI and temperatures that momentarily drop to −110° F.

This is only one of the many outstanding examples of how LINEAR "O" rings are serving industry and humanity on land, on sea, and in the air—everywhere that packings must stand rigid use with many different elements and pressures under a wide range of temperatures. "O" Ring Packings, made of natural or synthetic rubber compounds, are precision molded to extremely close tolerances. They are available in standard sizes from ⅛" to 15½" I.D., and in special sizes as required. LINEAR engineering experience is at your disposal. May we serve you?

*The use of "O" rings in certain packing structures is covered by Christensen Pat. No. 2,180,795 under which we have paid the royalty for the installation of our rings in these structures so that the royalty is included in the purchase price of the "O" ring.

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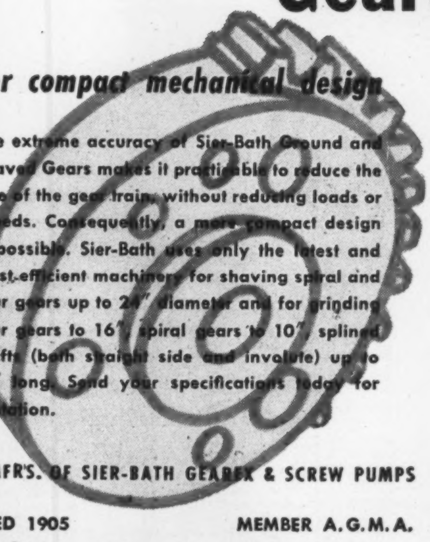

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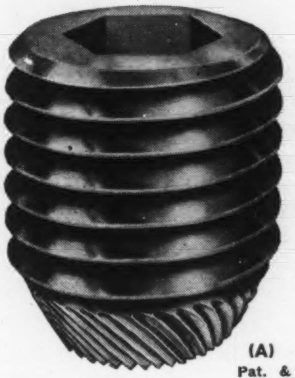

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KNURLED
CUP POINT**

(B)
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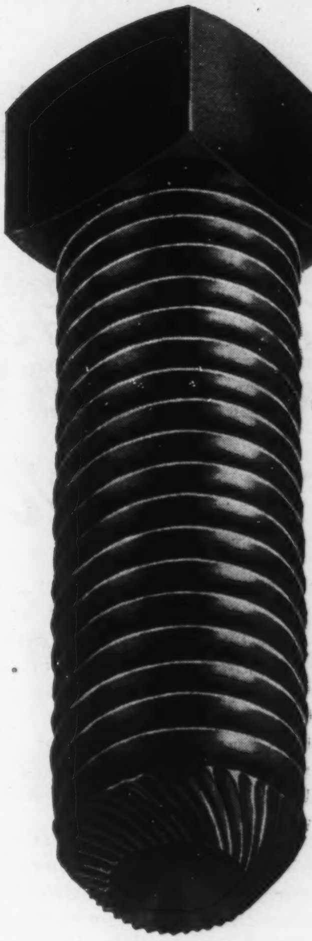
**"UNBRAKO"
KNURLED
THREAD**



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Pats. Pend.

**"UNBRAKO"
SQUARE HEAD
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...they won't shake loose!

Set screws must *"stay put"*. To make sure they do — Lock them! Yes, no matter what your set screw application may be—there's an "UNBRAKO" Self-Locking Set Screw to *lock* your requirements, because all patented "UNBRAKO" Set Screws are made SELF-LOCKING through KNURLING.

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Knurling of Socket Screws originated with "Unbrako" in 1934.

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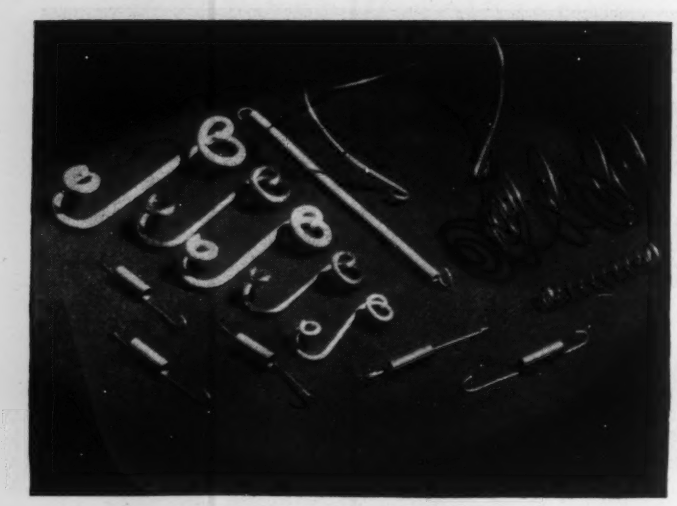

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Springs

Springs can make or break your product. Our quality control system has been mathematically worked out to hold every spring in every batch as near perfection as humanly possible. Uniformity in shape and size saves *you* assembly time. Avoidance of deviation in all other important characteristics enables each spring to *do the job* it is assigned.

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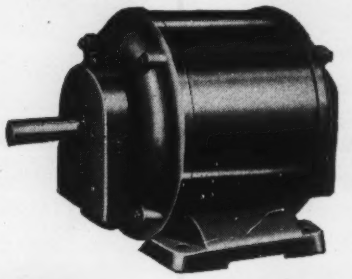
This **MOTOR** *comes from a large Family!*

VALLEY Ball Bearing Motors are built in sizes from ½ hp up to 75 hp, providing wide adaptability in power planning. VALLEY'S cool running splash proof, dust proof construction insures long hours of dependable power under the most hazardous conditions.



You'll find the type of Motor you need in your power planning when you investigate VALLEY MOTORS.

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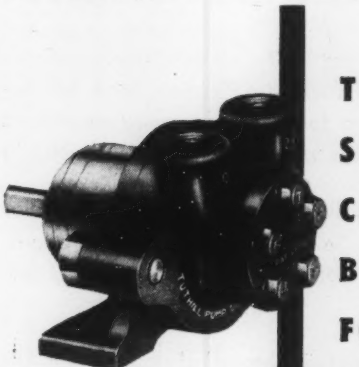

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It's the Tuthill Model L . . . a positive displacement, internal-gear rotary pump with the famous Tuthill mechanical seal. Capacities up to 3 g.p.m. at pressures to 400 p.s.i. Ring or foot mounting. Many porting arrangements to meet designers' needs. Write for Model L bulletin.

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HOW MUCH IS *enough lip* IN AN OIL SEAL?

CLIPPER SEALS provide a ready answer to this important question . . . because they are available in various lip designs, and with different lip durometers to meet specific shaft-wear and sealing conditions.

Moreover, this soft, pliable lip of the Clipper Seal is held in light but firm contact with the shaft by means of a specially designed garter spring. This permits lip pressure to be varied to the needs of the application—further assurance of minimum wear on both the shaft and the seal.

The rigid outer heel and flexible inner lip of the Clipper Seal are concentrically molded *as a single unit* to provide an unusually long-wearing oil seal with superior lubricant-retaining, dirt-excluding qualities. Made in both split and endless types, Clipper Seals are entirely non-metallic, are quickly installed, and easily removed without damage. They are for sealing against oil, grease, water, air, grit, and coolants and are furnished in sizes from ¼" I.D. up to 66" O.D.

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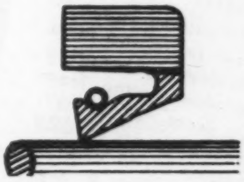
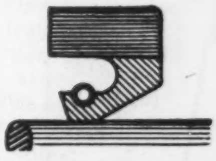
JOHNS-MANVILLE JM PRODUCTS

TYPICAL CLIPPER SEAL DESIGNS

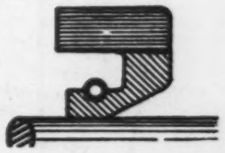
TYPE LA



TYPE R



TYPE B

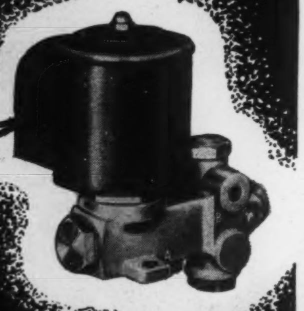


Clipper Seals are available with lips of varied design to meet many different working conditions. Here are shown sectional views of three types: LA, line contact lip; R, narrow contact lip; B, broad contact lip.

Johns-Manville ***PACKINGS & GASKETS***

ASCO Solenoid VALVES

Effective Automatic Control for Cylinders and Power Heads



It's versatile, this ASCO 3-way Solenoid Valve, for it can be found controlling air and hydraulic cylinders on hundreds of different machines, including:

air, gas and refrigerating compressors (for unloading)
tire moulding machines
plastic moulding presses
furnace and oven doors
conveyors of many types
metal working presses

Being "packless," maintenance is negligible. The stainless steel seats and discs (up to 3/8" size) are beveled, tight-seating and renewable. Pipe sizes range from 1/8" to 3/8". 1/8" to 1/2"; port sizes from 1/8" to 1/2"; It's suitable for pressures up to 500 pounds and temperatures up to 212° F. Other ASCO 3-way Valves up to 4" pipe size available.

This ASCO Solenoid Valve (Bulletin 8300) and its many companions in the broad ASCO Line are backed by more than 60 years of experience in the design and manufacture of automatic control units. This is your assurance of (1) getting the correct solenoid valve for your control problem and (2) getting a reliable valve.

When in need of Automatic Transfer Switches, Remote Control Switches, Contactors, Relays, and Specialized Electromagnetic Controls, come to us.

Automatic Switch Co.

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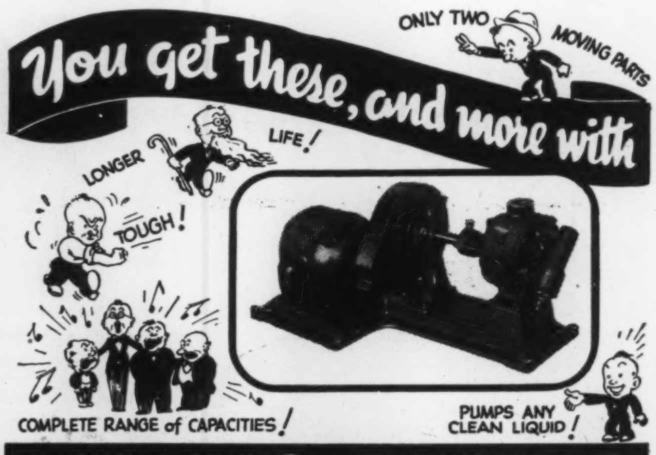
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And a dependable pump that is built to do the job intended.

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Cedar Falls, Iowa

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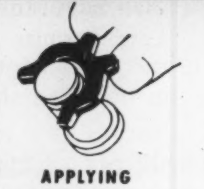

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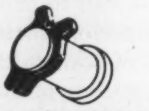
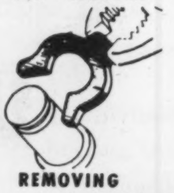


360° CLOSURE



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The Standard X Washer is an efficient, economical locking device. It provides quick, positive assembly . . . 360° closure to support greater thrust load . . . fast, easy removal . . . simplified service or repair. No vibration can shake it loose.

Standard X Washers are available for pin diameters from 7/32" to 17/32". For complete specifications write for Bulletin 26.

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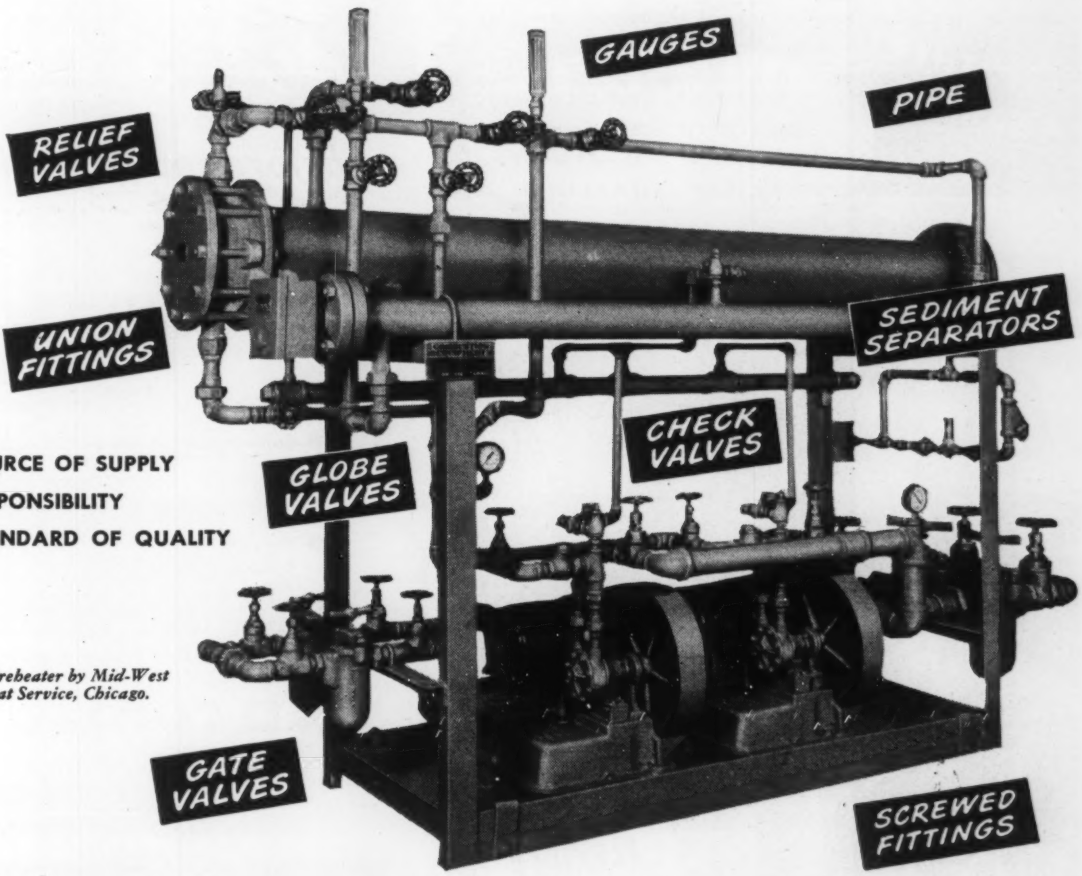

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Reliable power transmission — simple, safe design — made possible with STOW FLEXIBLE SHAFTING

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STOW
FLEXIBLE
SHAFTING

Courtesy — Wikomi Manufacturing Co.

Transmits POWER from Horizontal Take-Off to Vertical Drive Shaft

- In this seeder-spreader STOW Flexible Shafting transmits power from the tractor's power take-off through a 90° bend to a rotor in the hopper. As the rotor revolves, seed or mineral fertilizer is whirled out and spread over the soil.
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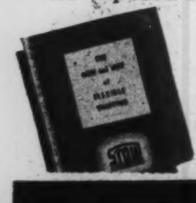

STOW Flexible Shafting is often your best answer to a particularly difficult power transmission problem. Write for data booklet, "The How and Why of Flexible Shafting"—*it's FREE.*

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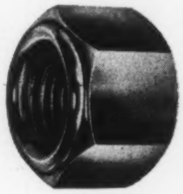

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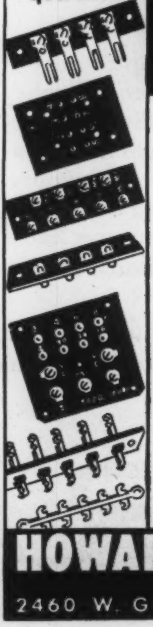
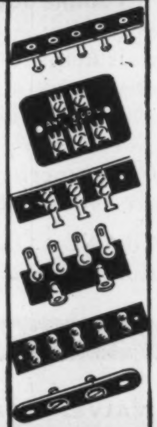
SPECIALS



Several pages of Jones Catalog No. 17 illustrate standard and special panels we are constantly producing. Latest special equipment enables us promptly to produce practically any panel required. Send print or description for prices, without obligation. Hundreds of standard terminal strips also listed. Send for Catalog, with engineering drawings and data.

JONES MEANS
Proven QUALITY



HOWARD B. JONES DIVISION
Cinch Mfg. Corp.
2460 W. GEORGE ST CHICAGO 18, ILL.

TRY this Low Cost Pump for:

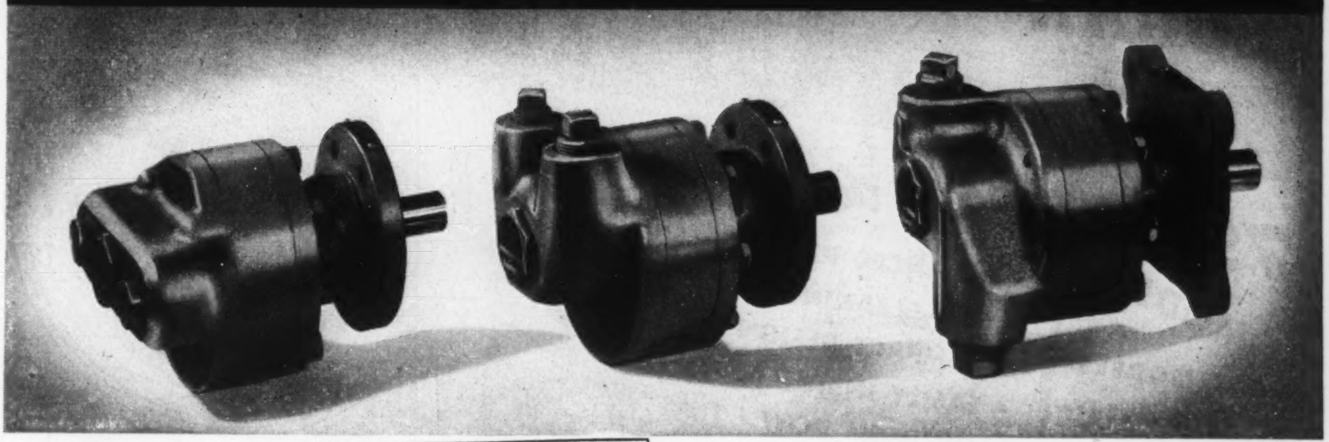


Illustration shows the Model 5W with porting arrangements that can be furnished. Two styles of flange mountings are shown and foot mounting bracket can be furnished (extra) if desired.

QUIET, EFFICIENT OPERATION

The Sundstrand Model 5W pump incorporates the outstanding Rota-Roll principle and pumping members which are responsible for the quiet, efficient operation in over 1,500,000 pumps. Because the basic elements are common to many other Sundstrand hydraulic units, the cost of the 5W pump is low.

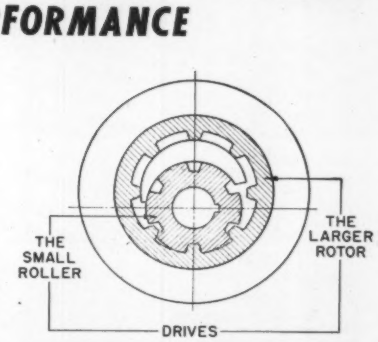
Try it on the following:

Materials handling equipment, agricultural machinery, industrial heating units, lift trucks, and similar equipment can be improved through the application of the Model 5W.

THESE FEATURES INSURE ITS QUIET, EFFICIENT PERFORMANCE

Rota Roll Principle

of pumping members promotes quiet operation, longer life because smaller roller is keyed to shaft and drives outer member at a speed 25% lower than motor speed.



Smooth, Uniform Flow at all Pressures because rotating roller and rotor are self-emptying, eliminating turbulence and other interference with smooth, uniform flow of oil.

Small and Compact (see illustration) will lend itself to and improve your product appearance.

High Overall Efficiency at maximum continuous duty pressure.

3 Standard Porting Arrangements. Another desirable feature of the Model 5W is its versatility in mounting and porting. The illustration above shows porting arrangements that can be furnished, making the pump adaptable to practically any piping requirements.

Available in 7 Sizes Ranging from 4 to 10 GPM. The Model 5W is furnished in 7 different capacities ranging from 4 to 10 GPM at 1200 RPM. Capacities are determined by width of pumping members, and all 7 sizes of pumps with the same combination of porting and mounting arrangement have the same basic dimensions excepting overall length. The pump is suitable for 1200 PSI service and operation at speeds up to 1800 RPM.

Low Cost because the basic elements of this efficient constant volume pump are common to many other Sundstrand hydraulic units. Sheave or pulley type drive pump can also be furnished.

FREE Additional Data

will be furnished on request. Write today, ask for M39.

THE SUNDSTRAND MODEL 5W
QUIET . . . EFFICIENT . . . LOW COST
Constant Volume Pump

6 OUTSTANDING FEATURES

SUNDSTRAND
HYDRAULIC DIVISION

SUNDSTRAND MACHINE TOOL CO.
ROCKFORD, ILLINOIS, U.S.A.

SUNDSTRAND HYDRAULIC DIVISION
2559 ELEVENTH STREET • ROCKFORD, ILLINOIS

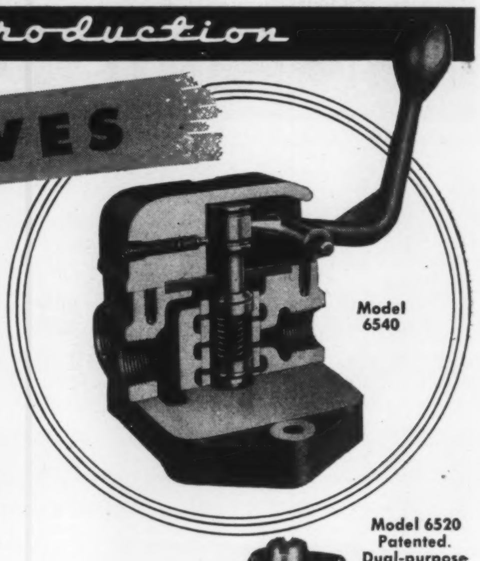
FUEL UNITS • HYDRAULIC PUMPS • TRANSMISSIONS • FLUID MOTORS • VALVES and CONTROLS

* Fluid Power Improves Production

"LOGAN"
AIR CONTROL VALVES

79
MODELS
MOST MODELS
STOCK DELIVERY

Check these Features!
- BALANCED PISTON DESIGN
- SELF-CLEANING
- COMPACT DESIGN
- EASILY INSTALLED
- MINIMUM DOWN TIME


Model 6540

Model 6520 Patented. Dual-purpose valve.

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SAVES
★ TIME
★ EFFORT
★ MOTION
Air and Hydraulic Equipment
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811 Center Ave.
Logansport, Indiana

*ENGINEERING SERVICE
Ask for Logan engineering assistance in designing complete air circuits. No obligation.

FREE CATALOG
Send for your free copy of air control valve catalog No. 90. Contains complete listing plus illustrations and diagrams.

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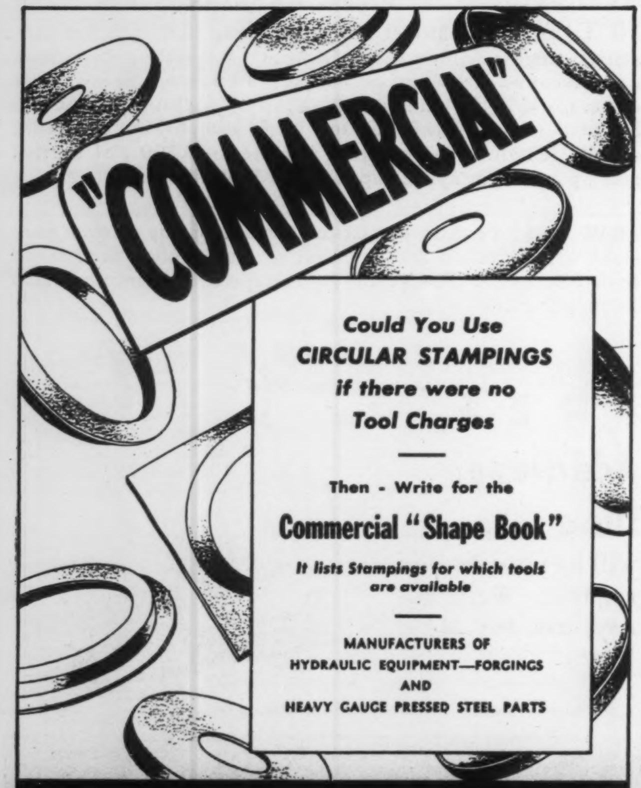
FLUID POWER SPECIALISTS SINCE 1916



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CIRCULAR STAMPINGS
if there were no
Tool Charges

Then - Write for the
Commercial "Shape Book"
It lists Stampings for which tools are available

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HYDRAULIC EQUIPMENT—FORGINGS
AND
HEAVY GAUGE PRESSED STEEL PARTS

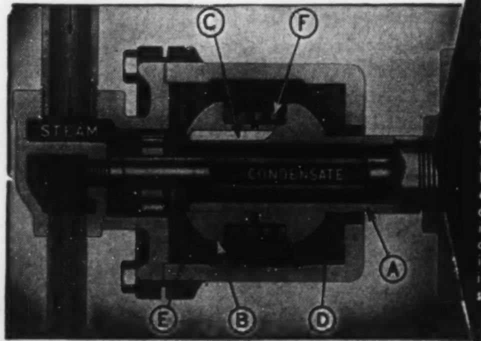
The Commercial Shearing & Stamping Company
YOUNGSTOWN 1, OHIO
MAIN OFFICE—Youngstown, Ohio
Factories in Youngstown, Ohio and Chicago, Ill.

Help FOR YOUR STUFFING BOX PROBLEMS . . .

JC

Getting steam or liquids into rotating machine parts used to mean a lot of trouble with stuffing boxes and steam fits. The Johnson Joint has changed all that. It's completely packless, self-oiling, self-adjusting and even self-aligning. Industry is finding new uses for it every day. Type B illustrated provides for condensate removal; other styles and sizes for all needs. Write for details.

THE JOHNSON CORPORATION
811 WOOD ST., THREE RIVERS, MICH.



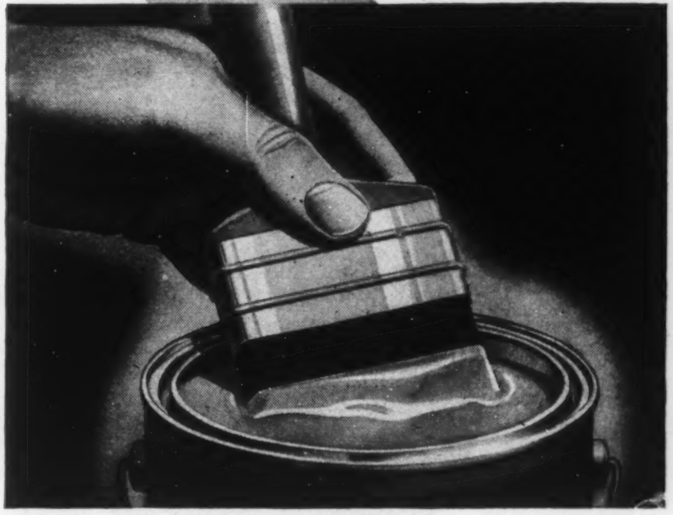
Nipple (A) connected to roll. Collar (B) is keyed (C) to nipple, but fits loosely so pressure can fill housing and force seal ring (D) in place. Both rings (D and E) are of carbon graphite, eliminate oiling and packing. Spring (F) is for initial seating only.

JOHNSON Rotary Pressure JOINTS

TO MAKE A GOOD PAINT BETTER USE G-E SILICONE OIL

Paint manufacturers have found that by adding small quantities of General Electric silicone oil they can eliminate the separation of pigments which causes mottled or streaky paint surfaces. Similarly, the "orange peel" look of certain lacquers has been avoided by the addition of G-E silicone oil.

How G-E Silicones can help you



Could your manufacturing efficiency be increased by using chemically inert materials that maintain thermal stability at extreme temperatures? Then you'll want to explore the possibilities of General Electric silicone products.

G-E SILICONE RUBBER. This material will not soften at 520 F, or become brittle at –70 F. It is available in extruded shapes, in compression-molded sheets, in paste form, or in tailormade compounds to meet specific requirements.

G-E SILICONE OILS. Their relatively stable viscosity at temperatures as high as 400 F, or as low as –90 F, recommend these oils for dielectric or hydraulic liquids, for cooling or heating baths, and as mold release agents.

G-E SILICONE EMULSIONS. As mold release agents, these water-diluted emulsions help to assure smooth castings and quick release—reduce the break-in time of new molds.

G-E SILICONE GREASES. Because of their resistance to chemicals and heat, these are excellent lubricants for plug cocks and valves. They also provide the heavier-bodied release agents needed in the tire and mechanical rubber goods industries.

WANT TO KNOW MORE ABOUT G-E SILICONES? Write us about *your* production problems. Let us help you solve them with one or more of these remarkable materials. Section 35-3, Chemical Department, General Electric Company, Pittsfield, Mass.

SILICONES

You can put your confidence in

GENERAL ELECTRIC

CD49-Q3

HIGH TORQUES?

DE LAVAL SPEED REDUCERS

For low final speeds Worm Gear Speed Reducers should be selected on the basis of output torque ratings.

If your problem is to select a gear reducer capable of carrying high torques, consult De Laval, either directly or through a sales representative.

DE LAVAL
DE LAVAL

ONE OF 93

This double reduction De Laval Worm Gear Speed Reducer is available with many standard gear ratios and is but one of 93 sizes and types of standard De Laval Worm Gear Speed Reducers.

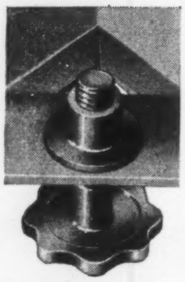
Worm Gear Division

DE LAVAL WG-11

De Laval Steam Turbine Co., Trenton 2, N. J.

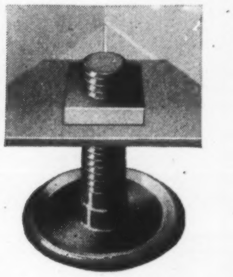
TURBINES • HELICAL GEARS • WORM GEAR SPEED REDUCERS • CENTRIFUGAL PUMPS
CENTRIFUGAL BLOWERS AND COMPRESSORS • IMO OIL PUMPS

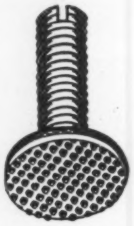
OHIO *Adjustable* FEET



Type FS has scallop rim. Cut shows application. Foot screwed into Ohio Flanged Weld Nut.

Type FR has solid rim. Cut shows usage with Ohio Square Weld Nut.





Non-skid feet are made to order. Cut shows slotted end. These are also available with square end.

Send for Bulletin 483!

THE OHIO NUT & BOLT COMPANY
620 N. Front St. Berea, Ohio.

TRACING CLOTH FOR HARD PENCILS

• Imperial Pencil Tracing Cloth has the same superbly uniform cloth foundation and transparency as the world famous Imperial Tracing Cloth. But it is distinguished by its special dull drawing surface, on which hard pencils can be used, giving clean, sharp, opaque, non-smudging lines.

Erasures are made easily, without damage. It gives sharp, contrasting prints of the finest lines. It resists the effects of time and wear, and does not become brittle or opaque.

Imperial Pencil Tracing Cloth is right for ink drawings as well.

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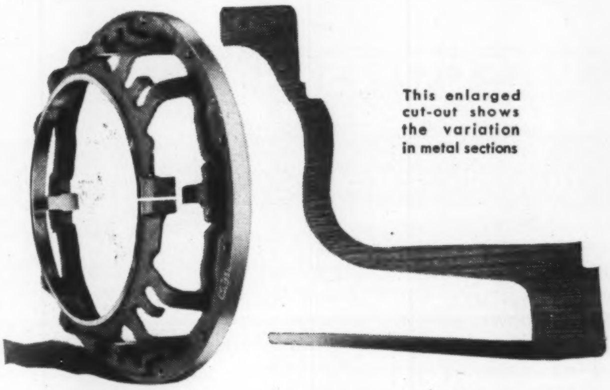

This enlarged cut-out shows the variation in metal sections

It's a Steel Casting...

This is a clutch cover plate that rotates at speeds up to 1,850 RPM—the heart of an improved fluid drive unit manufactured by the Twin Disc Clutch Company for the Allis Chalmers Corporation. Allis Chalmers uses the part in their HD-19 tractor—the largest track-laying tractor in the world.

When several other foundries attempted to produce this part, scrap loss exceeded 30%. Excessive shift, distortion, shrinkage and blowholes were often discovered *after the casting had been machined.* In spite of the high cost, Twin Disc engineers seriously considered redesigning the plate as a weldment.

Then Twin Disc brought us their problem. *We are now producing the plate at normal cost . . . with an abnormally low scrap loss percentage!*

If you have a casting problem, do as Twin Disc engineers did. Call on us.

CALUMET STEEL CASTINGS CORP.
1636 SUMMER STREET
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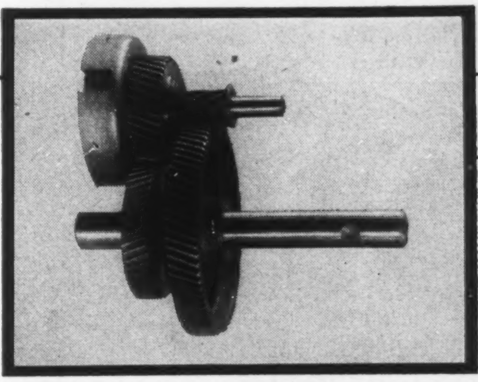
CALUMETAL

• Quiet
• Smooth
• Efficient

ECLIPSE
2-Speed Transmission



FOR MOTORS UP TO ½ H. P.

Transmits Constant Motor Speed into 2 Different Pulley Shaft Speeds!

SPEED RATIOS
Low Gear: pulley shaft to motor .14
High Gear: pulley shaft to motor .76
High to low: 5.4
Can be varied for specific requirements

This efficient 2-speed transmission is one of the most widely used of its type; it operates quietly and smoothly, can be manually, mechanically or electrically controlled, will give you years of economical and dependable service at low initial cost of installation. Variable gear sizes are available and additional gears and shafts can be added. If desired, case, clutch or gear elements can be purchased separately or in any combination. It's made by the makers of the famous Bendix* Starter Drive.

*REG. U.S. PAT. OFF.

For full particulars, write direct to

ECLIPSE MACHINE DIVISION of
ELMIRA, NEW YORK

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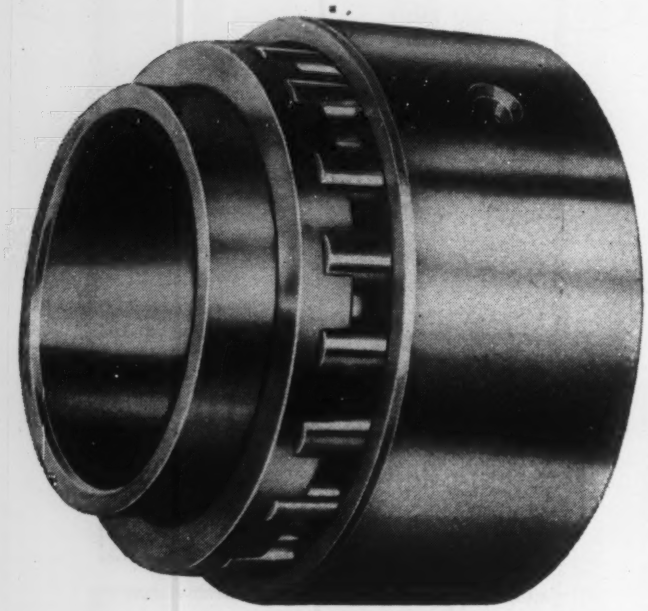
American

"*Extra*" Heavy-Duty

Roller Bearings

for the toughest anti-Friction jobs



Here is a "super" bearing designed especially for *super heavy-duty* service. Its simple construction, absolute precision and tremendous strength assure smooth, dependable performance in the heaviest machinery under the most difficult operating conditions. Complete technical data furnished without obligation. Write.

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HEAVY DUTY

Pacific Coast Office: 1718 S. Flower St., Los Angeles, Calif.

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Special Fasteners
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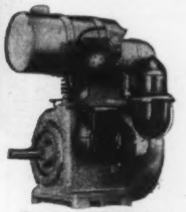
MAKERS OF **DOT** *FASTENERS*

WISCONSIN
Heavy-Duty *Air-Cooled* Engines
Offer Reputability
TO MATCH YOUR OWN . . .

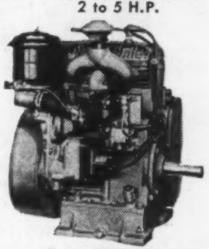
If your company manufactures power-operated equipment of any kind that can utilize engine power within a 2 to 30 Horsepower range . . . your good name is safe when the performance of your equipment is entrusted to Wisconsin Air-Cooled Engines.

Here is reputability to match your own, no matter how high or exacting your standards may be. Every Wisconsin Engine from the smallest to the largest is of heavy-duty design and construction. The perfectly balanced drop-forged crankshaft of every Wisconsin Engine runs on tapered roller bearings at *both* ends to take up end- and radial thrusts . . . a typical detail of Wisconsin heavy-duty design that assures the user "Most H.P. Hours" of on-the-job service.

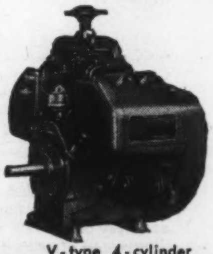
Wisconsin Heavy-Duty Air-Cooled Engines are available in 4 cycle single cylinder, 2- and 4-cylinder types in a complete power range up to 30 H.P.



Single cylinder sizes 2 to 5 H.P.



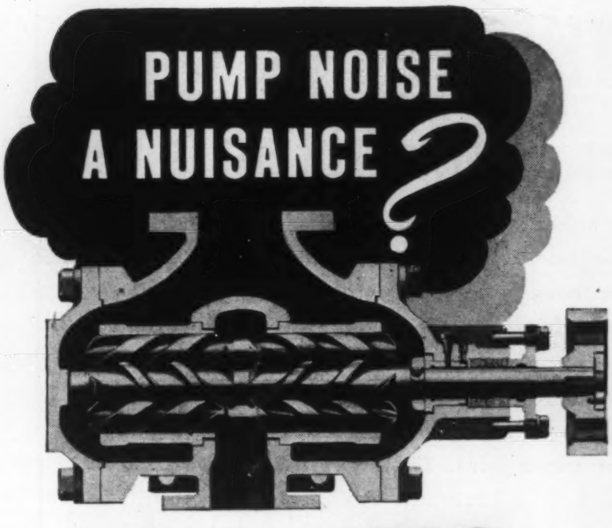
Two cylinder sizes, 7 to 13 H.P.



V-type 4-cylinder sizes, 15 to 30 H.P.

MOST H.P. HOURS

WISCONSIN MOTOR CORPORATION
World's Largest Builders of Heavy-Duty Air-Cooled Engines
MILWAUKEE 14, WISCONSIN, U.S.A.
Cable Address: WISMOTORCO



Install an **IMO**

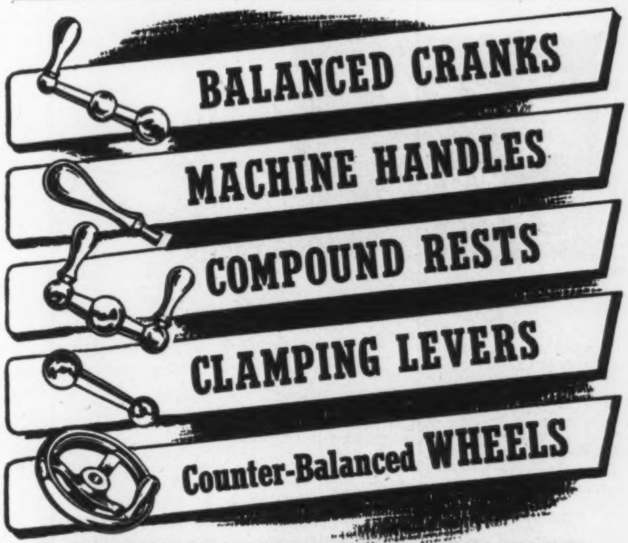
The IMO Pump has no valves, reciprocating parts, or gears to cause noise and vibration. The rotors of the IMO oil pump turn smoothly and quietly.

IMO pumps can be furnished for practically any capacity and pressure required for oil, hydraulic-control fluids and other liquids.

Send for Bulletin I-144. D.

IMO means I MOVE OIL

IMO PUMP DIVISION of the
DE LAVAL STEAM TURBINE CO.
TRENTON 2, NEW JERSEY



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● The result of over forty years experience, Balcrank "know how" brings you machine tool accessories of the finest quality and appearance—and at much less than the cost of your own production.

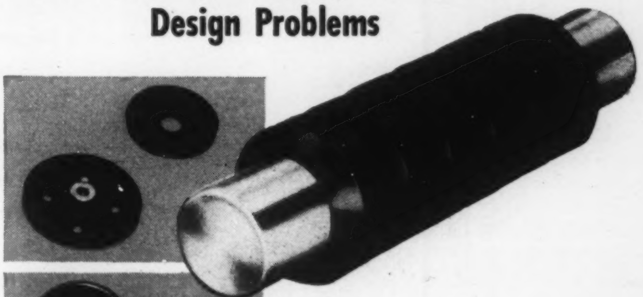
All Balcrank handles and accessories are cut from solid bar steel. They are specially coated and sealed to reach you in perfect condition.

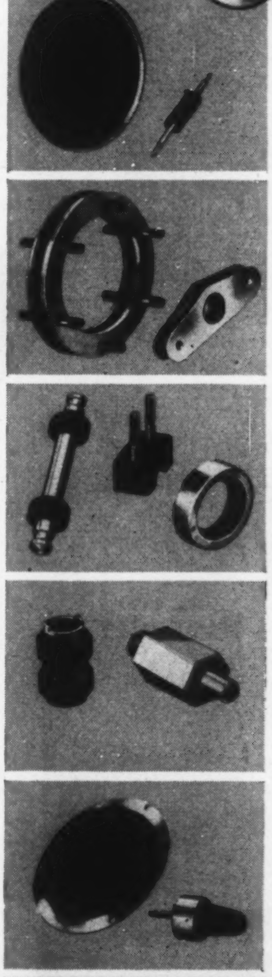
For specifications of standard units and complete information, write to Department M.

BALCRANK INC.
CINCINNATI 9, OHIO

RUBBER . . . with a backbone of STEEL

LORD BONDED-RUBBER Products Solve Some of Industry's Toughest Design Problems



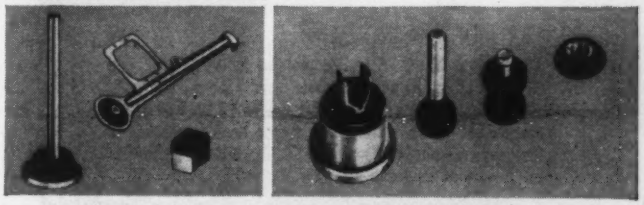


Rubber, bonded to metal by the LORD Process, gives the imaginative engineer what amounts to a new material with which to work—"rubber with a backbone of steel." Other metals, such as brass and dural, are also used to meet special conditions.

The characteristics of rubber, natural and synthetic,—its effective vibration control, its flexibility, its high coefficient of friction, its resistance to abrasion,—these qualities may be employed to fullest advantage because of the inseparable bond between the rubber and the substantial base to which it is attached.

Valve seats, motor mounts, idler wheels, diaphragms, pirn adapters, torsion joints, bearing seals, are a few of the successful applications which have been made and are suggestive of opportunities for improvement of other products. The Lord Bonded-Rubber Process combines the rigidity and strength of metal with the resiliency of rubber in a permanent bond that withstands strains and stresses of torsion, compression, or other distortion.

The greatest storehouse of practical experience in product improvement, through the application of rubber-bonded-to-metal, is at your service. Consult the Lord representative in your territory, or write.

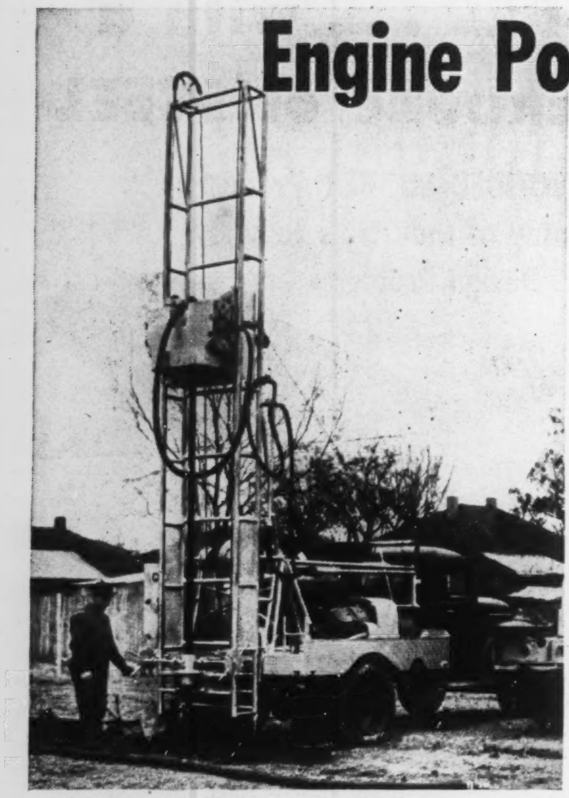


LORD MANUFACTURING COMPANY, ERIE, PA.
Canadian Representative: Railway & Power Engineering Corp. Ltd.

LORD Vibration Control Systems

Engine Power That Hangs On

When Earth Drilling is Tough

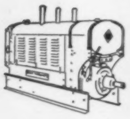


Drilling 5-in. hole for seismographic survey with earth boring machine manufactured by Hugh B. Williams Machine Co., Dallas, Texas. This model is driven by Allis-Chalmers B-125 Power Unit.

In boring holes for pier foundations, telephone poles or seismographic surveys, Williams Earth Drilling Machines frequently must bore through hard pan, slate or rock. That's when Allis-Chalmers high-torque power units show their ability to "hang on"—just like steam power—and handle hard drilling with ease.

Designed for tough tractor service, Allis-Chalmers engines provide heavy-duty power for any type of operation, continuous or intermittent. Their low first cost plus reliable, low-cost performance promotes customer satisfaction. So do the nation-wide service facilities. Let our power engineers help select the correct unit to fill your requirements.

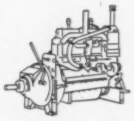
POWER UNITS — Five Sizes



ENCLOSED

Model*	Cyl.	R.P.M.	Max. B. HP.
B-125	4	1500-1800	24.5—28.0
W-201	4	1400-1800	33.5—40.5
U-318	4	1200-1400	45.0—50.9
E-563	4	1050	74.0
L-844	6	1050	110.0

*figures represent cu. in. displacement



OPEN STYLE

ALLIS-CHALMERS

TRACTOR DIVISION — MILWAUKEE 1, U. S. A.

Now
AVAILABLE
IN
PIPE SIZES
½ in. to 2 in.
CASH-ACME
TYPE E-41
Type E-41
PRESSURE REDUCING VALVE

The famous Type "E" ... so popular in the ½", ¾" and 1" pipe sizes, is now complete with 1¼", 1½" and 2" pipe sizes. Its ALL-BRONZE CONSTRUCTION and screwed-in seats, as well as Hycar seat washers and Neoprene diaphragm, mean a LONG LIFE of TROUBLE-FREE service on those big jobs you put in.

Sold ONLY through plumbing and heating wholesalers. See them. . . . Ask for . . . .

Write for your free copy of our new 1948 Catalog for complete details on CASH-ACME Products.

CASH-ACME *Automatic Valves . . . . . .*

A.W. CASH VALVE MANUFACTURING CORPORATION

6613 EAST WABASH AVENUE DECATUR, ILLINOIS, U. S. A.

RBM

Alternating Current

WORK SOLENOIDS

MORE POWER . . .
. . . IN LESS SPACE!
. . . AT LOWER COST

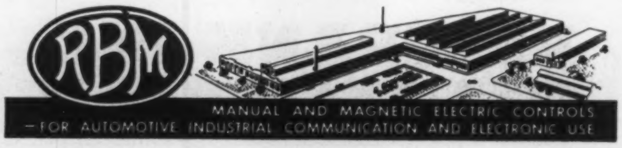
Electrical steel is wound to form cylindrical plunger. Impregnated coil enclosed in drawn frame. Assures low iron loss in less space than conventional stacked lamination construction.

Greater flexibility in mounting. Cylindrical plunger permits clevis to be rotated to any position.

Consider this solenoid where space and cost are factors. Available with continuous duty magnet coils to 600 volts A.C.

For more complete information write for Work Solenoid Bulletin No. 610. Address Department H-3.

R-B-M DIVISION, Essex Wire Corporation
Logansport, Indiana



MANUAL AND MAGNETIC ELECTRIC CONTROLS
—FOR AUTOMOTIVE INDUSTRIAL COMMUNICATION AND ELECTRONIC USE

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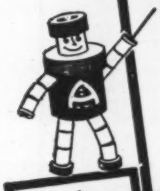
"SPECIAL BUSHINGS"

MAY BE OUR REGULAR

STOCK ITEMS!

Ready for Immediate Delivery

TWO complete bushing standards, the A.S.A. Standard plus our own Acme Standard, provides a much wider selection, enabling you to obtain bushings from stock that often would require special manufacture. Results in faster delivery, lower cost. Write for catalog.



Accurate
Interchangeable
Concentric

Acme Industrial Company

Makers of Hardened and Ground Precision Parts
211 N. Laflin Street • Chicago 7, Illinois

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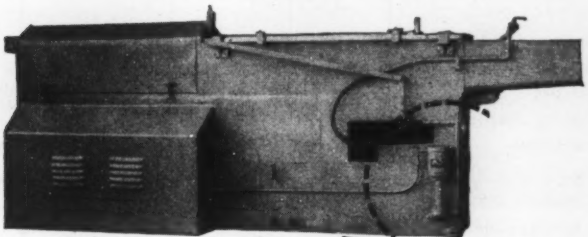
Here's why...

you get more production...



with a

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COOLANT PUMP

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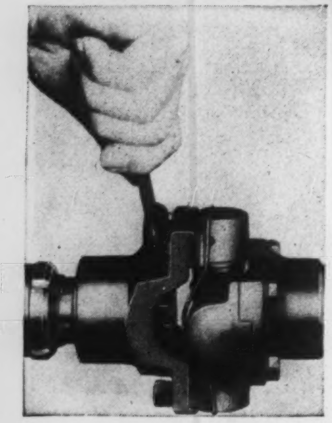
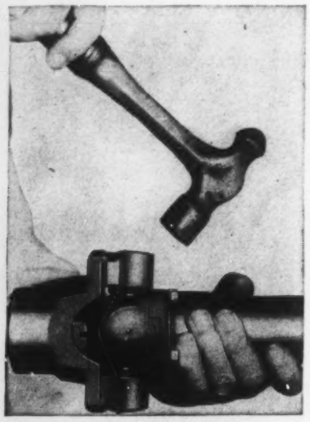


—with a wrench

to turn down the lock plates and remove the bolts — and to tighten and lock them again.



—and a hammer

to tap the tops of the bearings lightly to release them — and to compress the cork packing between the bearings and trunnions when the joint is reassembled.

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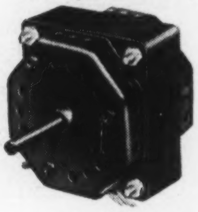
4-pole shaded pole motor. Approx. 1/30 h.p. 1550 r.p.m.



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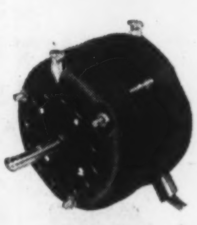

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Check these advantages!
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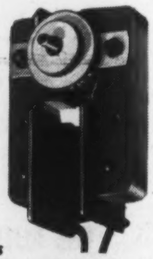

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2-pole shaded pole motor — full load h.p. .0021. Full load 2800 r.p.m.

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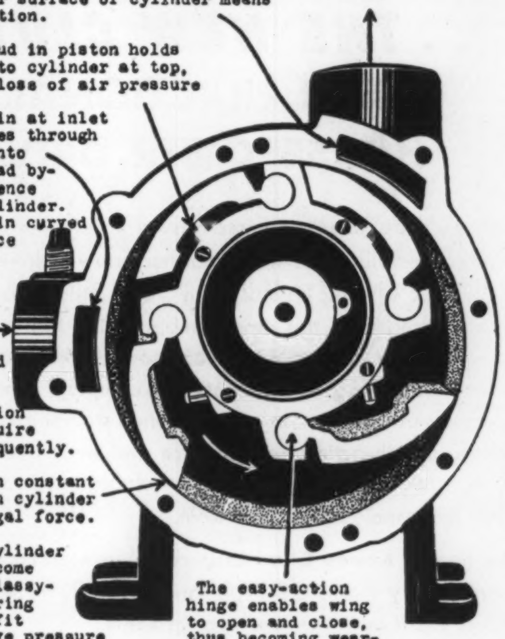

Air from cylinder through by-pass in cylinder head enters this slot on its way to the outlet above. No opening in curved inner surface of cylinder means quiet operation.

OUTLET threaded for iron pipe.

Enclosed stud in piston holds wing close to cylinder at top, preventing loss of air pressure or vacuum.

Air coming in at inlet at side comes through this slot into cylinder head by-pass and thence into the cylinder. No opening in curved inner surface of cylinder means quiet operation.

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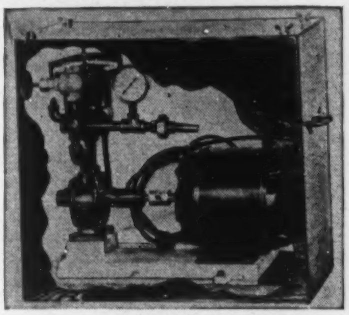

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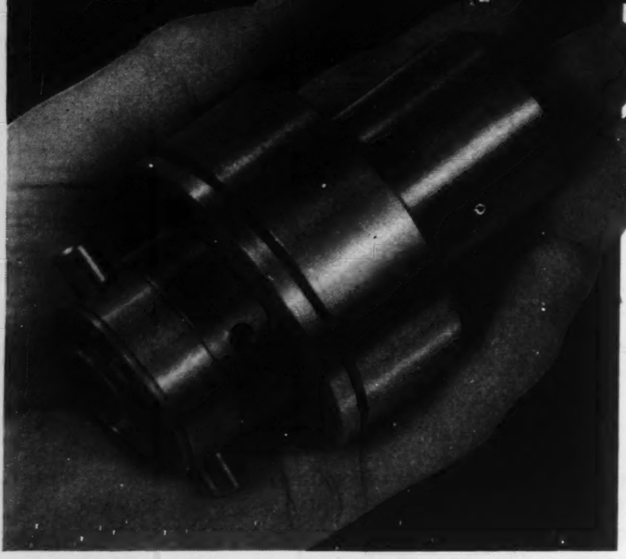

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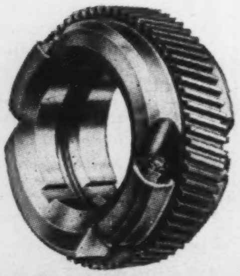

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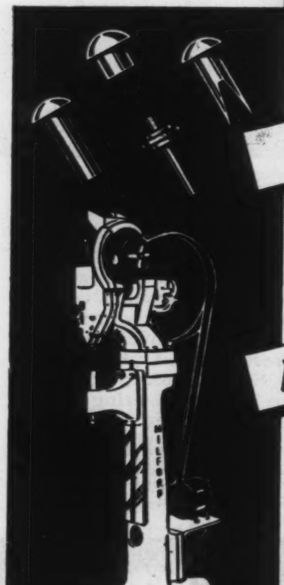

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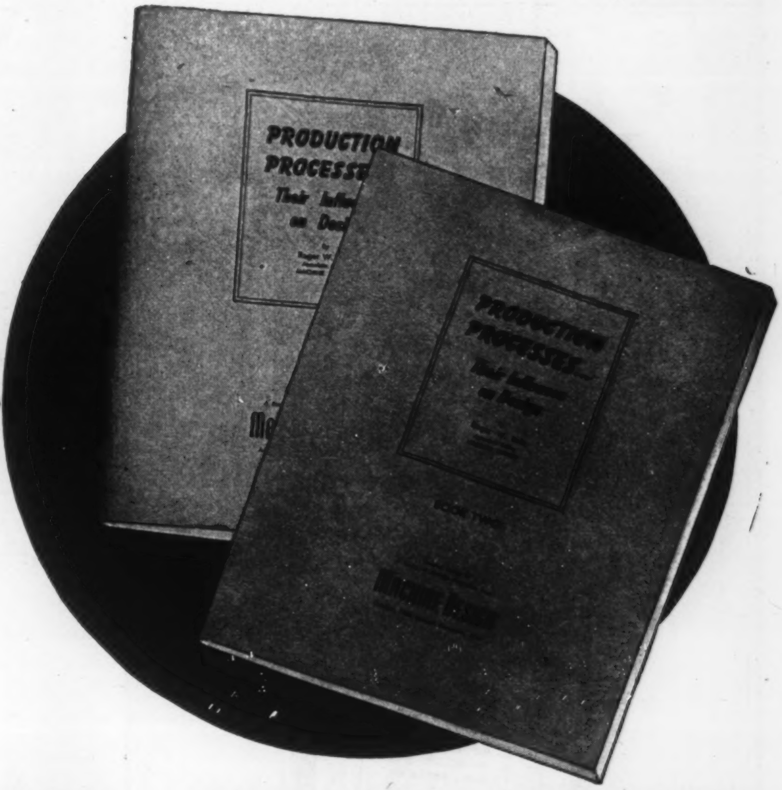

BY ROGER W. BOLZ
Associate Editor, Machine Design

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15 CHAPTERS OF
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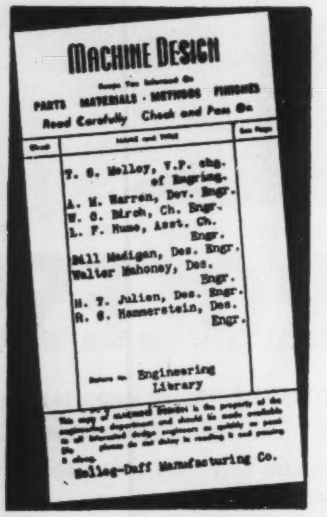

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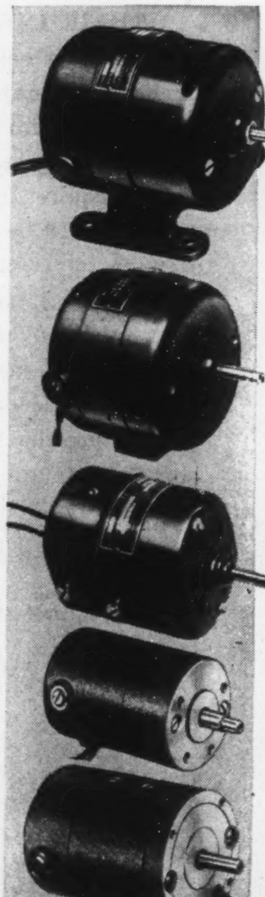

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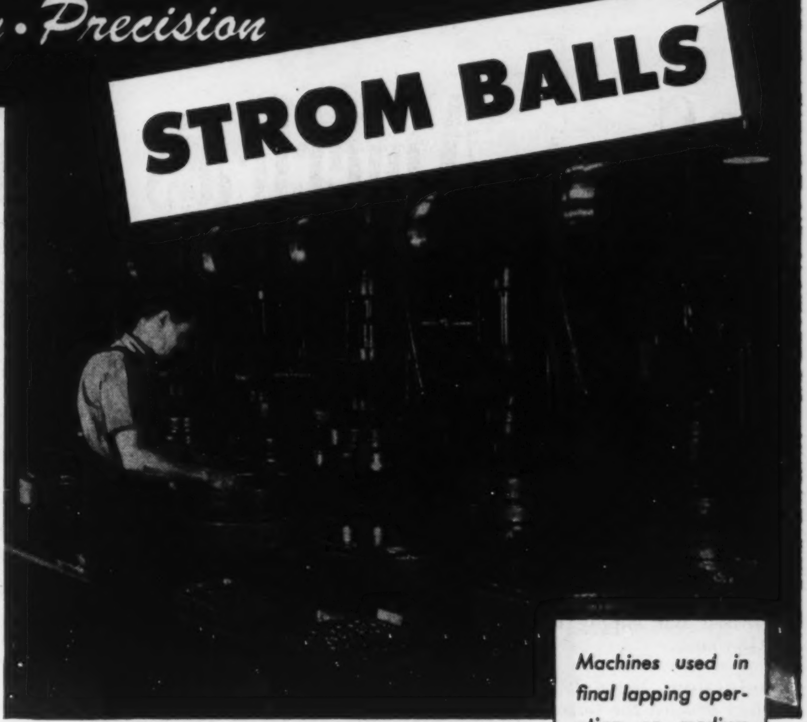

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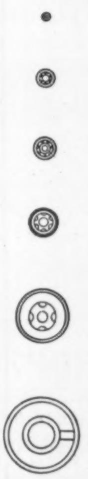

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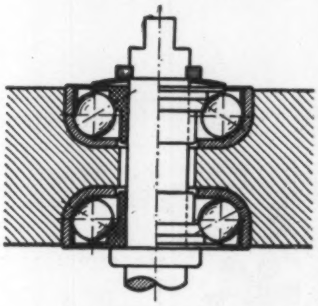

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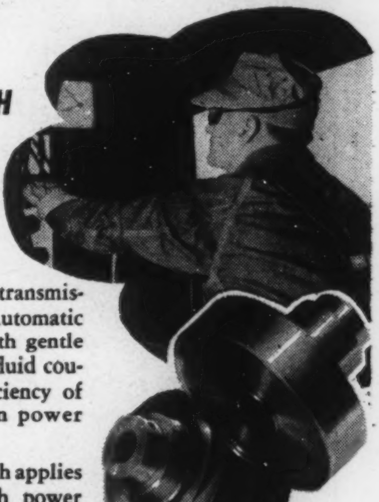

... the brains of a power transmission system. A Mercury Automatic Clutch combines the smooth gentle application of power of a fluid coupling with the 100% efficiency of a mechanically locked-in power transmission.

A Mercury Automatic Clutch applies to the load only as much power (torque) as the prime mover is designed to produce... with no damage to the electric motor or wiring from overloading and no stalling of gasoline engines. It utilizes... *automatically*... the maximum torque production of the prime mover at its most efficient speed. With motors you get maximum torque at minimum current consumption.

Consider a Mercury Automatic Clutch . . . for original equipment installations or wherever you use motors or gasoline engines in your plant.

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Mercury Clutch Division
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Income: Since 1910 we have increased our annual income from less than $2400 per household to about $4000 (in dollars of the same purchasing power.)

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American teamwork is management that pays reasonable wages and takes fair profits—that provides the best machines, tools, materials and working conditions it possibly can—that seeks new methods, new markets, new ideas; that bargains freely and fairly with its employees.

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Teamwork is simply working together to turn out more goods in fewer man-hours—making things at lower costs and paying higher wages to the people who make them and selling them at lower prices to the people who use them.

What we've already accomplished is just a foretaste of what we *can* do. It's just a start toward a goal we are all striving to reach: better housing, clothing, food, health, education, with ever greater opportunities for individual development. Sure, our American System has its faults. We all know that. We still have sharp ups and downs in prices and jobs. We'll have to change that—*and we will!*

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What we have already accomplished is just a foretaste of what we *can* do—if we continue to *work together!*

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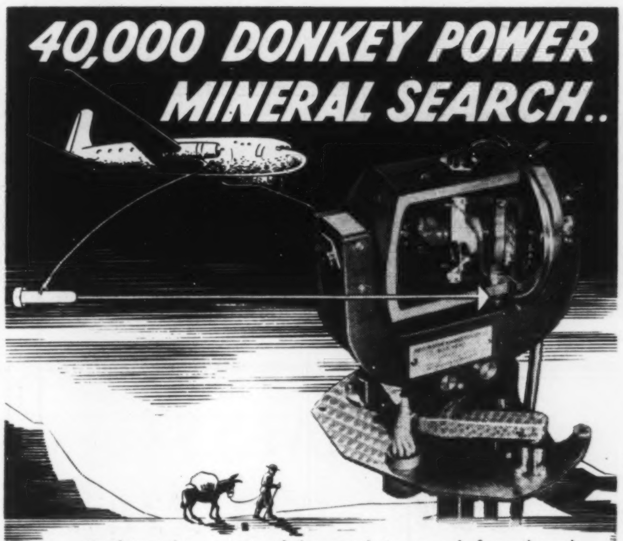

Probing the secrets of the earth in search for oil and ore at 150 miles an hour, the flying magnetometer (Gulf Research & Development Co.) has already carefully charted over ½ million square miles.

MPB is proud to have furnished components for these sensitive instruments — precision ball bearings which are also available for your newest development. A complete catalog will be promptly mailed on request. Specify data sheet. MD-39

MPB MINIATURE Precision BEARINGS
INCORPORATED
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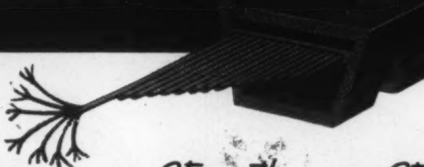
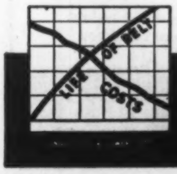
BROWNING
STEEL CABLE
GRIPBELTS



MORE Strength • LESS Stretch

GREATER STRENGTH • FEWER BELTS

LESS STRETCH • LESS SLIP



Browning Steel Cable Gripbelts are much stronger than ordinary belts. They will safely carry heavier loads with fewer belts. They will stretch less and give longer life without loss of power and efficiency.

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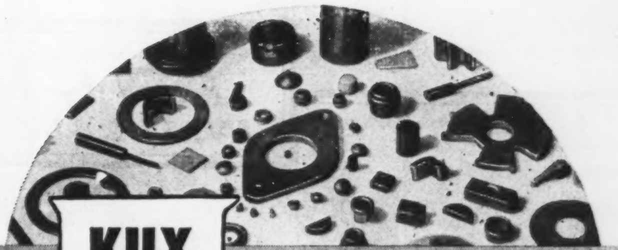

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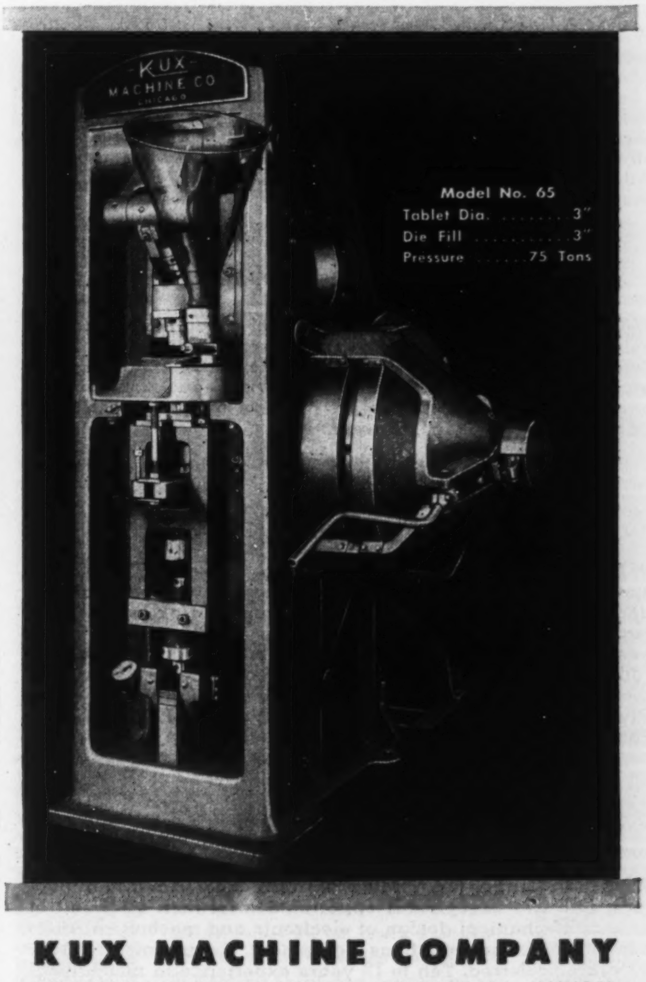

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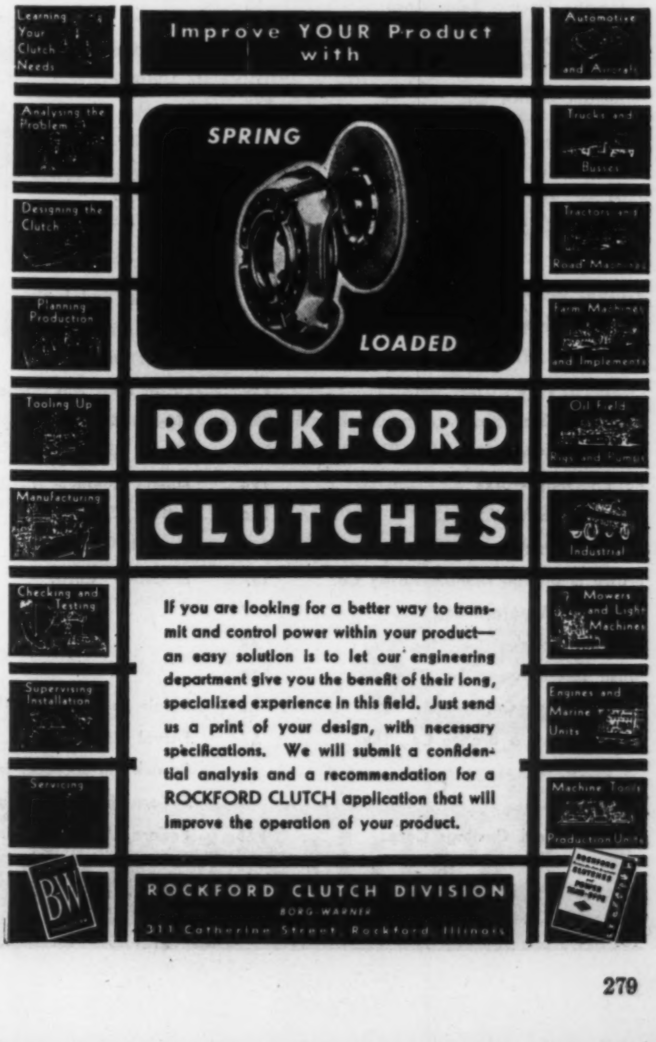

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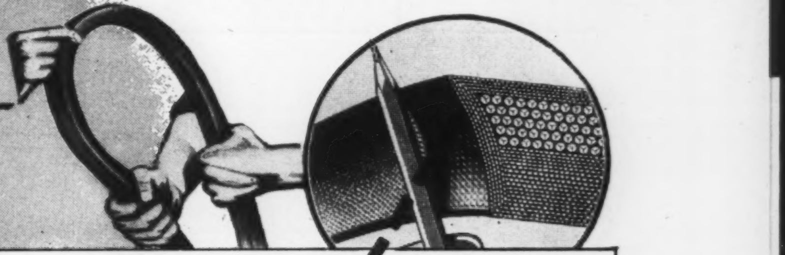
as the belt Bends —



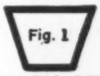
-That SHOWS you Exactly WHY THE CONCAVE SIDE

(U. S. PATENT NO. 1813698)

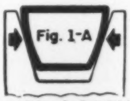
SAVES You MONEY

Bend any V-Belt and you can actually feel its sides change shape.

That's because the bending puts the top of the belt under *tension,* while the body undergoes *compression.* Naturally the sides of the belt *bulge out*—and if the belt is built with *straight sides,* you get the result shown in Figures 1 and 1-A, below:—



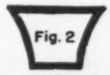
Straight-Sided V-Belt



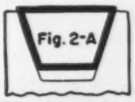
How Straight-Sided V-Belt Bulges in Sheave-Groove.

Clearly, the bending forces a straight-sided V-Belt into a shape that does not fit the sheave-groove—and the bulging produces excessive wear along the *middle* of the *sides.*

Now, bend the V-Belt built with the precisely engineered Concave Side (U. S. Patent No. 1813698)—the Gates Vulco Rope.



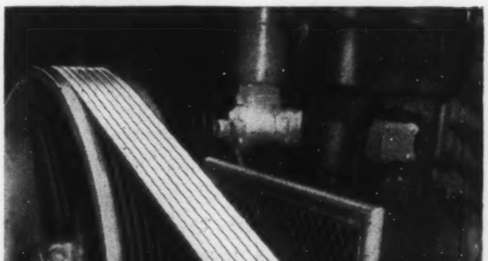
Gates Vulco Rope With Concave Side.



No Side Bulge. Precise Fit in Sheave-Groove.

You get the same shape change but *now* the new shape *exactly fits* the sheave-groove as shown in Figures 2 and 2-A.

Results—(1) *Uniform* side-wall wear; *longer* life. (2) *Full* sidewall grip on the pulley; carries heavier loads and sudden load increases without slippage — a big increase in drive efficiency — saving belt wear and also saving power!



The Concave Side is *MORE IMPORTANT NOW* Than Ever Before

Because the *sides* of a V-Belt are what actually *drive* the pulley, it is clear that any increased load on the belt means a heavier load that must be transmitted to the pulley *directly* through the belt's side-walls.

Now that Gates *SPECIALIZED* Research has made available to you SUPER Vulco Ropes—carrying fully 40% higher horsepower ratings—the life-prolonging Concave Side naturally delivers greater savings today than ever before.

THE GATES RUBBER COMPANY
DENVER, U. S. A.
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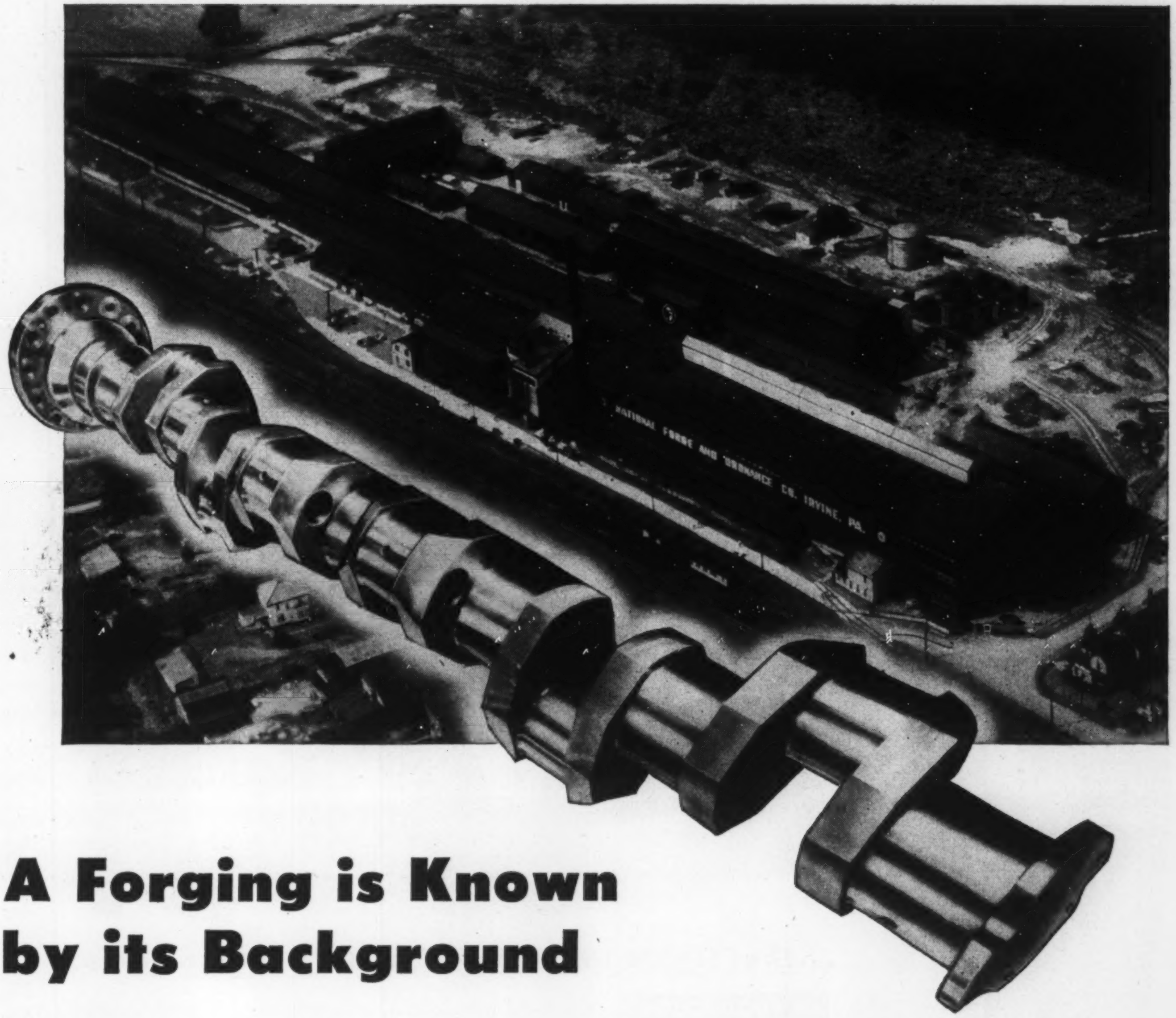

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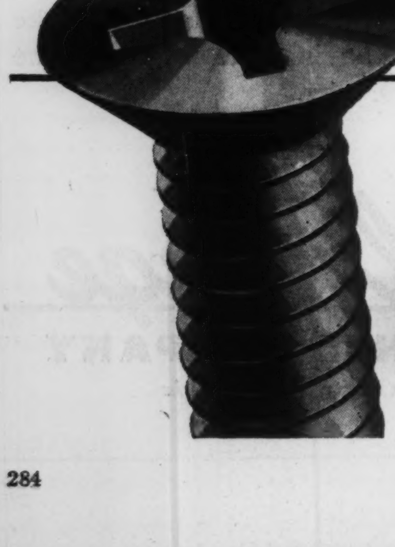

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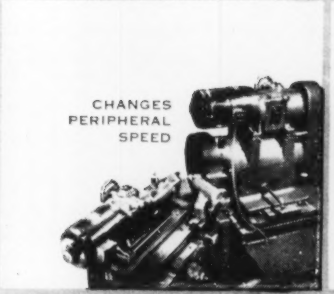
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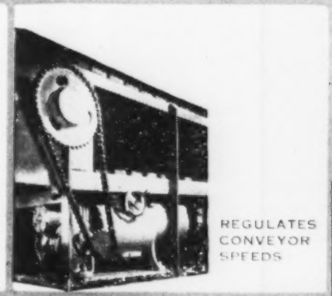
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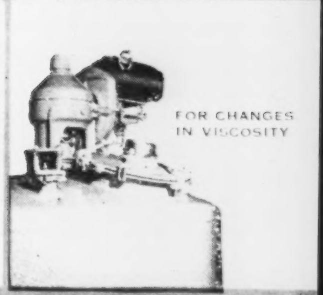
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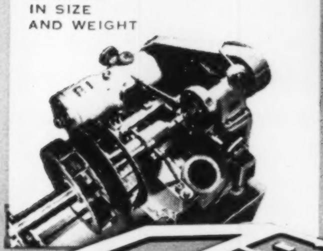
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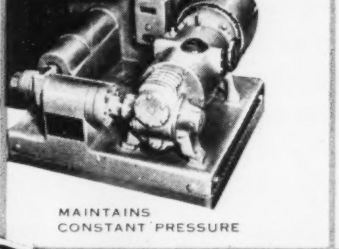
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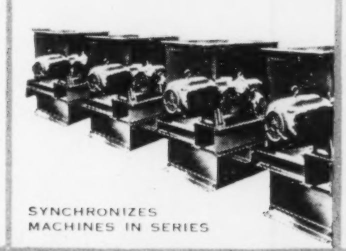
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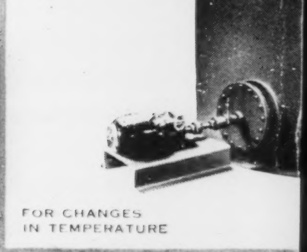
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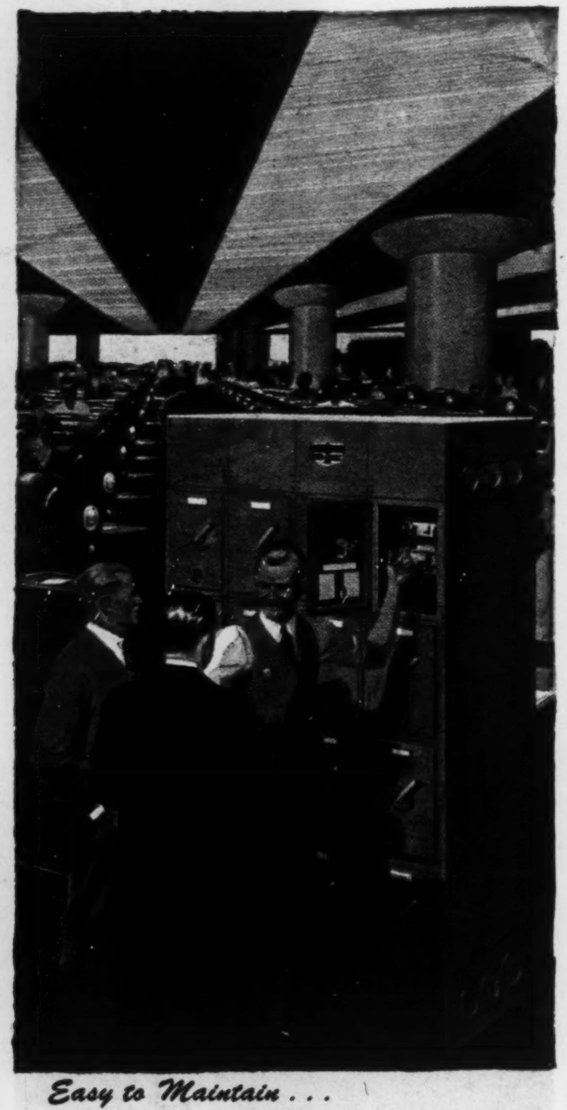

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